

SCHOOL SCIENCE

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In This Issue

ASTRONOMY IN SCIENCE AND IN HUMAN CULTURE

E-WAVES AND PARTICLES FUNDAMENTALLY DIFFERENT

NEW PATTERN OF THE PROCESS OF DIVISION

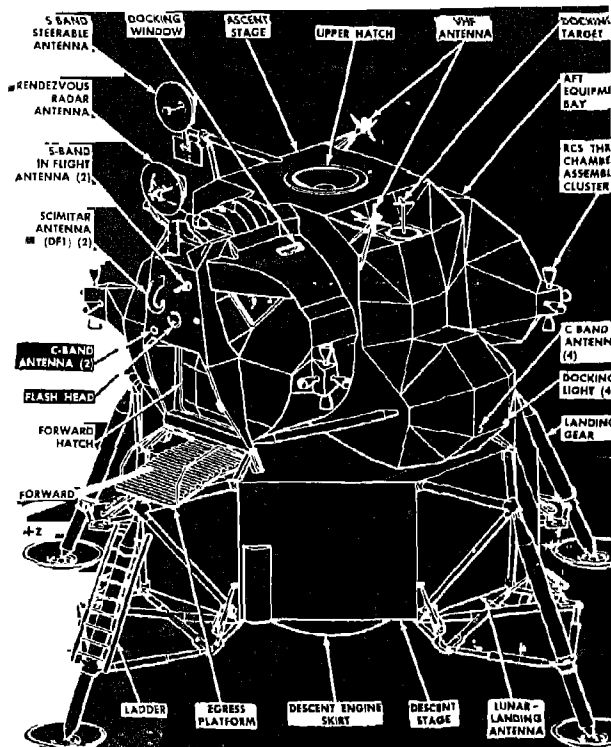
MAIN PRINCIPLES OF BIOLOGY SYLLABUS FOR SCHOOLS

ORGANIZATION AND CONTENT OF PRE-MEDICAL EDUCATION

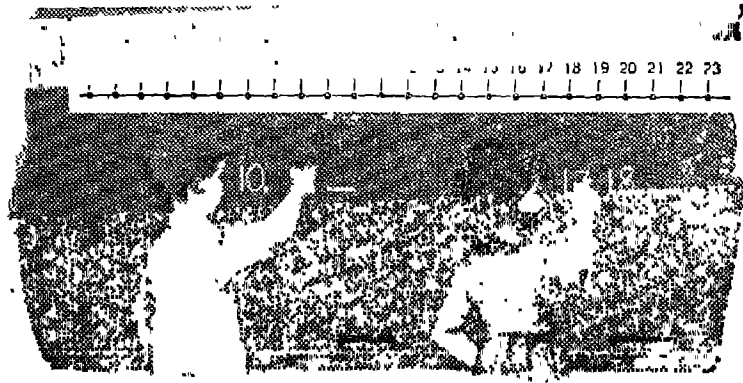
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CONTENTS

	Editorial		iii
	Astronomy in Science and in Human Culture	<i>Prof. S. Chandrasekhar</i>	1
	Are Waves and Particles Fundamentally Different	<i>Chhotan Singh</i>	12
<i>Chief Editor</i> M. C. PANT	A New Pattern of the Process of Division	<i>S. G. Dabhadkar</i>	15
	Finding the Greatest Common Divisor of two Positive Whole Numbers with the Help of Euclid's Algorithm	<i>R. C. Sharma</i> <i>V. J. Baulin</i>	18
<i>Associate Editor</i> S. DORAISWAMI	Study Rooms for Science Subjects	<i>W. P. Kuchama</i>	22
	Main Principles of Biology Syllabus for Middle and Senior High School	<i>S. Doraiswami</i> <i>V. M. Galushin</i> <i>G. R. Meyer</i>	26
	Duration and Content of Pre-Medical Education	<i>V. Ramalingaswami</i>	31
<i>Cover Photograph</i> <i>Courtesy: U.S.I.S.</i>	Role of Basic Researches in Biology and New Trends in Biology Teaching	<i>B. M. Johri</i> <i>S. L. Tandon</i>	36
	<i>Classroom Experiments</i>		
	Fun with Chemistry	<i>Y. I. Naumov</i> <i>N. K. Sanyal</i>	47
	The Medicine Dropper and a Simple Balance	<i>Hy Ruchlis</i>	50
	Improved Methods for Showing Convection Currents	<i>C. Ramakrishnayya</i>	53
	<i>Science Abroad</i>		
	New Light on Vision	<i>John Newell</i>	54
	A Lesson in Inequalities for the Twelfth Year Mathematics Student — Cauchy's Inequality	<i>Charles L. Riggs</i> <i>Paul E. Thompson</i>	57
	<i>Young Folks Corner</i>		
	A Scientific Deed	<i>S. A. Balezin</i> <i>M. C. Pant</i>	62 69
	Prof. Fred Hoyle FRS		
	<i>New Trends in Science Education</i>		
	Teaching of Biology as a Separate Discipline	<i>Mrs. Fathose</i>	71
	The Teaching of Chemistry as a Separate Discipline	<i>Miss Lalita Arora</i>	75
	Study Group in Mathematics, Jadavpur University.		78
	NCERT Mathematics Study Groups	<i>J. N. Kapur</i>	78
	Summer Science Institutes		81
	<i>Science Notes</i>		86
	<i>News and Notes</i>		92
	Problems in Mathematics	<i>R. C. Sharma</i>	96
	<i>Books for your Science Library</i>		97

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EDITORIAL

THIS number of 'School Science' opens with the Jawaharlal Nehru Memorial Lecture for 1969 delivered by Prof. S. Chandrasekhar. In this lecture, entitled *Astronomy in Science and in Human Culture* Prof Chandrasekhar traces the development of astronomy among Babylonians, Greeks and Hindus, and gives us an idea of how astronomy has dug back into the history of the universe and taken us nearer to a knowledge of how it originated. In the article that follows, *Are Waves and Particles Fundamentally Different*, Chottan Singh discusses how De Broglie's work has shown that waves and particles are not merely closely related to each other but are, in fact, different aspects of one and the same thing.

Three articles in this issue deal with mathematics—two at the junior level, and the third at a more advanced level. S.G. Dabhadker (*A New Pattern of the Process of Division*) describes a new and simple process of division for students of classes III and IV, while R.C. Sharma describes a simple method of obtaining the Greatest Common Divisor with the help of Euclid's algorithm. The third article gives an interesting discussion and proof of the Cauchy's Inequality under the feature "Science Abroad".

On science teaching, there are a number of articles. In *Duration and Content of Pre-medical Education*, V Ramalingaswamy makes the point that the main purpose of a pre-medical course is to develop a love of learning and a discipline of the mind; the content of the course is embedded in the framework of the natural sciences, humanities and the social sciences. W P Kurchania in *Study Rooms for Science Subjects* described in great practical detail how relatively inexpensive study rooms can be set up in schools for the different science subjects. Science, he says, requires to be taught by the experimental method, and pupils' activities are essential; full-scale laboratories, on the other hand, are very costly to equip and maintain, and they also suffer from a number of disadvantages—hence his suggestion for science study rooms.

Two extremely informative articles deal with biology teaching. In *Role of Basic Research in Biology and New Trends in Biology Teaching*, B.M. Johri and S.L. Tandon discuss how basic researches in biology are important in the teaching of biology at the senior level; they say that teaching methods as well as revision of the curriculum should go hand in hand with the advancement of knowledge, and discuss the transmission of research findings to the schools, encouraging teachers to undertake research, the use of teaching aids, evaluation of students, and the in-service training of teachers. In *Main Principles of the Biology Syllabus for the Middle and Senior High School*, S. Doraiswami, V.M. Galushin and G.R. Meyer discuss the syllabus—and its objectives and underlying principles—prepared by NCERT and UNESCO experts for teaching biology as a separate subject in middle and senior high schools.

Two more articles on science teaching must be mentioned here. Under the feature "New Trends in Science Education", two Delhi school teachers, Mrs. Pathrose of the Mother's International School and Miss Lalita Arora of the Government Girls Secondary School, Sarojini Nagar, describe their experiences in teaching their respective subjects (biology and chemistry) as separate subjects to middle classes under the NCERT Project. Middle school science teachers will perhaps find these two articles particularly stimulating.

Among the regular features of *School Science* in this issue, in "Classroom Experiments", Y.I. Naumov and N.K. Sanyal describe a number of interesting "magic" experiments to motivate school children in chemistry, and C. Ramakrishnayya describes an improved method for showing convection currents, while Hy Ruchlis gives some simple but interesting experiments with a medicine dropper and a simple balance

Under "Science Abroad" the main feature is an interesting account by John Newell of the work being done on the various problems involved in vision, at the London Institution of Ophthalmology. In the "Young Folks Corner", S.A. Balezin and M.C. Pant narrate, step by step, the developments that led eventually to the making of the Periodic Table by Mendeleev. There is also a short biographical sketch of Prof. Fred Hoyle, who has recently won the Kalinga prize. In "New Trends for Science Education", the complete programme of the Summer Science Institutes is given. "Science Notes", as usual, contains news of the latest developments in the different fields of science. And the highlight of "News and Notes" in this issue is a brief account of the Annual Conference of All India Science Teachers Association held in December 1968

In conclusion, we trust that readers will find this issue of *School Science* even richer, both in range and depth, than earlier numbers.

Astronomy in Science and in Human Culture

Jawaharlal Nehru Memorial Lecture 1969

PROFESSOR S. CHANDRASEKHAR,
Distinguished Service Professor of
Astrophysics, University of
Chicago

IT is hardly necessary for me to say how deeply sensitive, I am to the honour of giving this second lecture in this series founded in the memory of the most illustrious name of independent modern India. As Pandit Jawaharlal Nehru has written, "The roots of an Indian grow deep into the ancient soil, and though the future beckons, the past holds back."

I hope I will be forgiven if I stray for a moment from the announced topic of my lecture to recall, how forty-one years ago, I was one of thousands of students who went to greet young Jawaharlal (as we used to call him at that time) on his arrival to address the National Congress meeting in Madras that year.

I recall also how the dominant feeling in

all of us at that time was one of intense pride in the men amongst us and in what they inspired in us Lokamanya Tilak, Mahatma Gandhi, Lala Lajpat Rai, Motilal Nehru, Jawaharlal Nehru, Sardar Patel, Sarojini Naidu, Rabindranath Tagore, Srinivasa Ramanujan—names that herald the giants that lived amongst us in that pre-dawn era

The topic I have chosen for this lecture, "Astronomy in Science and in Human Culture," is so large that I am afraid that what I can say on this occasion can at best be a collection of incoherent thoughts. In the first part of the lecture I shall make some general observations on ancient Hindu astronomy, particularly with reference to the way it relates Hindu culture to the other cultures of antiquity. I am not in any sense a student of these matters. My knowledge is solely derived from the writings of a distinguished historian of science, Professor Otto Neugebauer, who has kindly helped me in preparing this part of my lecture.

In the second part of the lecture I shall say something about the particular role of astronomy in expanding the realm of man's curiosity about his environment.

One aspect of astronomy is certain: it is the only science for which we have a continuous record from ancient times to the present. As Abdul-Qasim Said ibn Ahmad wrote in 1068 in a book entitled, "*The Categories of Nations*": "The category of nations which has cultivated the sciences form an elite and as essential part of the creation of Allah." And he enumerated eight nations as belonging to this class: "The Hindus, the Persians, the Chaldeans, the Hebrews, the Greeks, the Romans, the Egyptians, and the Arabs".

Chronologically, the interactions between the leading civilizations of the ancient world are far more complex than this simple enumeration suggests. And a study of these interactions provides us with the most

impressive testimony to man's abiding interest in the universe around him.

We know today that Babylonian astronomy reached a scientific level only a century or two before the beginning of Greek astronomy in the fourth century B.C. The development of Hellenistic astronomy, after its early beginnings, to its last perfection by Ptolemy in 140 A.D. is largely unknown. Then about three centuries later Indian astronomy, manifestly influenced by Greek methods, emerged. This last fact raises the question as to the way in which this transmission of information from Greece to India took place. Its answer is made particularly difficult since it implies possible Persian intermediaries. Some centuries later, in the ninth century, Islamic astronomy appears influenced by Hindu as well as Hellenistic sources.

While the Greek astronomy rapidly became dominant in the eastern part of the Muslim world from Egypt to Persia, the methods of Hindu astronomy persisted in Western Europe even as late as the fifteenth century, as I shall indicate later.

As far as Babylonian astronomy is concerned, we know very little about its earlier phases. But it appears that a mathematical approach to the prediction of lunar and planetary theory was not developed before the fifth century B.C. that is to say barely prior to the corresponding stage of development of Greek astronomy. It is, however, generally agreed that the development of Babylonian astronomy took place independently of the Greeks.

An important distinction between the Babylonian and the Greek methods is this: Babylonian methods are strictly arithmetical in character and are not derived from a geometrical model of planetary motion; the Greek methods, on the other hand, have invariably had a geometric basis. This

distinction enables us to identify their influence in Hindu astronomy.

Let me make a few remarks on Greek astronomy as it is relevant to my further discussion.

The earliest Greek model that was devised to account for the appearance of planetary motion is that of Eudoxus in the middle of fourth century B.C. On this model planetary motion was interpreted as a superposition of uniform rotations about certain inclined axes. In spite of many glaring inadequacies, this model had a profound impact on subsequent planetary theory. The culmination of Hellenistic astronomy is, of course, contained in Ptolemy's "Almagest"—perhaps the greatest book on astronomy ever written; and it remained unsurpassed and unsurpassed until the beginning of the modern age of astronomy with Kepler.

Ptolemy's modification of lunar theory is of special importance for the problem of the transmission of Greek astronomy to India. The essentially Greek origin of the Surya Siddhanta which is the classical textbook of Hindu astronomy—cannot be doubted: it is manifested in the terminology, in the units used, and in the computational methods. But Hindu astronomy of the North does not appear to have been influenced by the Ptolemaic refinements of the lunar theory; and this appears to be true with planetary theory also. This fact is of importance: a study of Hindu astronomy will give us much needed information on the development of Greek astronomy from Hipparchus in 150 B.C. to Ptolemy in 150 A.D.

In early Hindu astronomy, as summarized by Varaha Mihira in the Pancha Siddhantika, we can distinguish two distinct methods of approach: the trigonometric methods best known through Surya Siddhanta and the arithmetical methods of Babylonian astronomy in the astronomy of the South. The

Babylonian influence has come to light only in recent years; and I shall presently refer to its continued active presence in the Tamil tradition of the seventeenth and the eighteenth centuries.

I should perhaps state explicitly here that the fact that Hindu astronomy was deeply influenced by the West does not by any means exclude that it developed independent and original methods. It is known, for example, that in Hindu astronomy the chords of a circle were replaced by the more convenient trigonometric function $\sin a$ —($R \sin a$).

Before I conclude with some remarks on the simultaneous existence of two distinct astronomical traditions in India I should like to illustrate my general remarks by two specific illustrations which are of some interest.

In 1825 Colonel John Warren, of the East India Company, stationed at Fort St. George, Madras, wrote a book of over 500 quarto pages entitled *Kala Sankalita with a Collection of Memoirs on the Various Methods According to Which the Southern Part of India divided Time*. In this book, Warren described how he had found a calendar maker in Pondicherry who showed him how to compute a lunar eclipse by means of shells placed on the ground and from tables memorized as he stated "by means of certain artificial words and phrases." Warren narrates that even though his informer did not understand a word of the theories of Hindu astronomy he was nevertheless endowed with a memory sufficient to arrange very distinctly his operations in his mind and on the ground." And Warren's informer illustrated his methods by computing for him the circumstances of the lunar eclipse of May 31—June 1, 1825 with an error of + 4 minutes for the beginning,—23 minutes for the middle, and—52 minutes for the end. But it is not the degree of accuracy of his

result that concerns us here; it is rather the fact that a continuous tradition still survived in 1825, a tradition that can be traced back to the sixth century A.D. with Varaha Mihira, to the third century in the Roman Empire and to the Seleucid cuneiform tablets of the second and the third centuries.

A second instance I should like to mention is an example of the survival of Hindu astronomy in parts of the Western world that were remote from Hellenistic influences during the medieval times. A Latin manuscript has recently been published which contains chronological and astronomical computations for year 1428 for the geographical latitude of Newminster, England. It used methods manifestly related to Surya Siddhanta. Obviously one has to assume Islamic intermediaries for a contact of this kind between England of the fifteenth century and Hindu astronomy.

While Surya Siddhanta manifests Greek influence, Babylonian influence has recently been established in the post-Vedic and pre-Surya Siddhanta period. For example, in the astronomy of that period, the assumption of a longest day of 18 muhurtas and a shortest day of 12 muhurtas were made. This ratio of 3:2 is hardly possible for India. But it is appropriate for Mesopotamia; and possible doubts about the Babylonian origin of this ratio were removed when the same ratio was actually found in Babylonian texts. In addition, a whole group of other parallels between Babylonian and Indian astronomy have since been established. Thus, the most characteristic feature of Hindu time reckoning—the tithis—occurs in Babylonian lunar theory.

Clearly all these facts must be taken into account in any rational attempt to evaluate the intellectual contacts between ancient India and the Western world. This problem of the foreign contacts is by no means the

only, or even the most important, fact that is to be ascertained. One must consider the Dravidic civilizations of the South on par with the history, the language, and the literature of the Aryan component of Indian culture. It is, as Neugebauer has emphasized, this dualism of Tamil and Sanskrit sources that will provide for us, eventually, a deeper insight into the structure of Indian astronomy.

In his book *"Rome Beyond Imperial Frontiers"* Sir Mortimer Wheeler comes to the conclusion that "the far more extensive contacts with South India have been a blessing to the archeologists" but he adds that "these contacts had no influence on these cultures themselves." Hindu astronomy provides an example to the contrary. Exactly as it is possible to distinguish between commercial contacts which India had through the Punjab or through the Malabar and Coromandal Coast, it is possible to distinguish the astronomy of the Surya Siddhanta on the one hand and the Tamil methods on the other. This distinction is indeed very marked. The Surya Siddhanta is clearly based on pre-Ptolemaic Greek methods while the Tamil methods, in their essentially arithmetical character, manifest the influence of Babylonian astronomy of the Seleucid—Parthian period.

One must not, of course, conclude that the Tamil methods were imported directly from Mesopotamia while the geometric methods came to the North via the Greeks and through, Persian intermediaries. And as I stated earlier, the fact that the Surya Siddhanta appears to have not been influenced by the Ptolemaic refinements, provides an important key to the development of Hellenistic astronomy between the times of Hipparchus and Ptolemy.

A proper assessment of the role of Hindu science in the ancient world has yet to be

made. The problem is made more difficult, than is necessary, by the tendency of the majority of publications of Indian scholars to claim priority for Hindu discoveries and to deny foreign influence, as well as the opposite tendency among some European scholars. These tendencies on both sides have been aggravated by the inadequate publication of the original documents: this is indeed the most pressing need. Since no astronomy at an advanced level can exist without actual computations of planetary and lunar ephemerides, it must be the first task of the historian of Hindu astronomy to search for such texts. Such texts are indeed preserved in great numbers, though actually written in very late periods. But the publication of this material is an urgent need in the exploration of oriental astronomy.

Let me conclude this somewhat incoherent account, bearing on the ancient culture of India, by emphasizing that its principal interest lies not in the sharing or in the apportioning of credit to one nation or another but rather in the continuing thread of common understanding that has bound the elite nations of Abul-Qasim ibn Ahmad in man's constant quest to comprehend his environment.

The pursuit of astronomy at the more sophisticated level of modern science, since the time of Galileo and Kepler, is concerned with the same broad questions even though that fact is often observed by the technical details of particular investigations.

Questions that may naturally occur to one often appear to be meaningless in the context of current science. But with the progress of science questions that appear as meaningless to one generation become meaningful to another. It is to this aspect of the development of astronomy in recent times that I should like to turn my attention now.

The first question that I shall consider

concerns the assumption that is implicit in all sciences. Nature is governed by the same set of laws at all places and at all times, i.e. Nature's laws are universal. That the validity of this assumption must be raised and answered in the affirmative was the supreme inspiration which came to Newton as he saw the apple fall. Let me explain.

Galileo had formulated the elementary laws of mechanics governing the motions of bodies as they occur on the earth, and the laws he formulated were based on his studies of the motions of projectiles, of falling bodies, and of pendulums. And Galileo had, of course, confirmed the Copernican doctrine by observing the motions of the satellites of Jupiter with his telescope. But the question whether a set of laws could be formulated which governed equally the motions of all bodies, whether they be of stones thrown on the earth or of planets in their motions about the sun, did not occur to Galileo or his contemporaries. And it was the falling apple that triggered in Newton's mind the following crucial train of thought.

All over the earth objects are attracted towards the center of the earth. How far does this tendency go? Can it reach as far as the moon? Galileo had already shown that a state of uniform motion is as natural as a state of rest and that deviations from uniform motion must imply force. If then the moon were relieved of all forces, it would leave its circular orbit about the earth and go off along the instantaneous tangent to the orbit. Consequently, so argued Newton, if the motion of the moon is due to the attraction of the earth, then what the attraction really does is to draw the motion out of the tangent and into the orbit. As Newton knew the period and the distance of the moon, he could compute how much the moon falls away from the tangent in one second. Com-

paring this result with the speed of falling bodies, Newton found the ratio of the two speeds to be about 1 to 3600. And as the moon is sixty times farther from the center of the earth than we are, Newton concluded that the attractive force due to the earth decreases as the square of the distance. The question then arose: If the earth can be the center of such an attractive force, then does a similar force reside in the sun, and is that force in turn responsible for the motions of the planets about the sun? Newton immediately saw that if one supposed that the sun had an attractive property similar to the earth, then Kepler's laws of planetary motion become explicable at once. On these grounds, Newton formulated his law of gravitation with lofty grandeur. He stated: "Every particle in the universe attracts every other particle in the universe with a force directly as the product of the masses of the two particles and inversely as the square of their distance apart." Notice that Newton was not content in saying that the sun attracts the planets according to his law and that the earth also attracts the particles in its neighbourhood in a similar manner. Instead with sweeping generality, he asserted that the property of gravitational attraction must be shared by all matter and that his law has universal validity.

During the eighteenth century, the ramifications of Newton's laws for all manner of details of planetary motions were investigated and explored. But whether the validity of Newton's laws could be extended beyond the solar system was considered doubtful by many. However, in 1803 William Herschel was able to announce from his study of close pairs of stars that in some instances the pairs represented real physical binaries revolving in orbits about each other. Herschel's observations further established that the apparent orbits were ellipses and

that Kepler's second law of planetary motion, that equal areas are described in equal times, was also valid. The applicability of Newton's laws of gravitation to the distant stars was thus established. The question whether a uniform set of laws could be formulated for all matter in the universe became at last an established tenet of science. And the first great revolution in scientific thought had been accomplished.

Let me turn next to the second great revolution in explicit context of astronomy that was accomplished during the middle of the last century.

During the eighteenth century the idealist philosopher Bishop Berkeley claimed that the sun, the moon, and the stars are but so many sensations in our mind and that it would be meaningless to inquire, for example, as to the composition of the stars. And it was an oft-quoted statement of Auguste Comte, a positivist philosopher, influential during the early part of the nineteenth century; that is in the nature of things that we shall never know what the stars are made of. And yet that very question became meaningful and the center of astronomical interest very soon afterwards. Let me tell this story very briefly.

You are familiar with Newton's demonstration of the chapter of white light by allowing sunlight to pass through a small round hole and letting the pencil of light so isolated fall on the face of a prism. The pencil of light was dispersed by the prism into its constituent rainbow colours. In 1802 it occurred to an English physicist, William Wollaston, to substitute the round hole, used by Newton and his successors to admit the light to be examined with the prism, with an elongated crevice (or slit as we would now say) $1/20$ th of an inch in width. Wollaston noticed that the spectrum thus formed, of light "purified" (as he stated) by the abolition of over-

lapping images, was traversed by seven dark lines. These Wollaston took to be the natural boundaries of the various colours. Satisfied with this quasi-explanation, he allowed the subject to drop. The subject was independently taken up in 1814 by the great Munich optician Fraunhofer. In the course of experiments of light, directed towards the perfecting of his achromatic lenses, Fraunhofer, by means of a slit and a telescope, made the surprising discovery that the solar spectrum is crossed not by seven lines but by thousands of obscure streaks. He counted some six hundred and carefully mapped over three hundred of them. Nor did Fraunhofer stop there. He applied the same system of examination to other stars; and he found that the spectra of these stars, while they differ in details from that of the sun, are similar to it in that they are also traversed by dark lines.

The explanation of these dark lines of Fraunhofer was sought widely and earnestly. But convincing evidence as to their true nature came only in the fall of 1859 when the great German physicist Kirchhoff formulated his laws of radiation. His laws in this context consist of two parts. The first part states that each substance emits radiations characteristic of itself and only of itself. And the second part states that if radiation from a higher temperature traverses a gas at a lower temperature, glowing with its own characteristic radiations, then in the light which is transmitted the characteristic radiations of the glowing gas will appear as dark lines in a bright background. It is clear that in these two prepositions we have the basis for a chemical analysis of the atmospheres of the sun and the stars. By comparisons with the spectral emissions produced by terrestrial substances, Kirchhoff was able to identify the presence of sodium, iron, magnesium, calcium, and a host of other

elements in the atomosphere of the sun. The question which had been considered as meaningless only a few years earlier had acquired meaning. The modern age of astrophysics began with Kirchhoff and continues to the present. And we all know that one of the major contributions to our understanding of the spectra of stars and the physics of stellar atmospheres was made in our own times by Meghnad Saha.

Now I come to a question that man has always put to Nature: Was there a natural beginning to the universe around us? Or to put the question more directly. How did it all begin? All religions and all philosophical systems have felt the need and the urge to answer this question. Indeed, one may say that a theory of the universe, a theory of cosmology, underlies all religions and all myths. And one of the earliest cosmologies, formulated as such, occurs in the Babylonian epic *Enuma Elish* in the second millennium B.C. The poem opens with a description of the universe as it was in the beginning:

*When a sky above had not been mentioned
And the name of firm ground below had
not been thought of
When only primeval Apsu, their begetter,
And Mummu and Ti'amat—she who gave
birth to them all—
Were mingling their waters in one;
When no God whosoever had appeared,
Had been named by name had been deter-
mined as to his lot,
Then were Gods formed within them.*

Whether the question of the origin of the universe can be answered on rational scientific grounds is not clear. It might be simplest to suppose that in all aspects the astronomical universe has always been. Or, alternatively, following Comte we might even say that it is in the nature of things that we shall never

know how or when the universe began. Nevertheless, recent discoveries in astronomy have enabled us for the first time to contemplate rationally the question: Was there a natural beginning to the present order of the astronomical universe? A related question is: If the astronomical universe did have a beginning, then are we entitled to suppose that the laws of Nature have remained unchanged? The two questions are clearly related.

Let me take the second question first. Have the laws of Nature remained the same? Can the universality of Nature's laws implied by Newton in his formulation of the laws of gravitation, be extended to all time in a changing universe?

It is clear that over limited periods of time the laws of Nature can be assumed not to have changed. After all, the motions of planets have been followed accurately over the past three centuries—and less accurately over all historical times—and all we know about planetary motions has been accounted for with great precision with the same Newtonian laws and with the same value for the constant of gravitation. Moreover, the physical properties of the Milky Way system have been studied over most of its extent—and its extent is 30,000 light years. It can be asserted that the laws of atomic physics have not changed measurably during a period of this extent. And on the earth geological strata have been dated for times which go back several hundreds of millions of years. In particular the dating of these strata by the radio-active content of the minerals they contain assumes that the laws of physics have not changed over these long periods. But if during these times the astronomical universe in its broad aspects has not changed appreciably then the assumption that the laws have not changed appreciably during these same periods would appear to be a natural one. The questions that I have formulated, to have

meaning, must be predicted on the supposition that there is a time scale on which the universe is changing its aspect. And if such a time scale exists, the first question is: What is it?

That a time scale characteristic of the universe at large exists was first suggested by the discoveries of Hubble in the early twenties. There are two parts to Hubble's discoveries. The first part related to what may be considered as the fundamental unit or constituents of the universe. It emerged unequivocally from Hubble's studies that the fundamental units are the galaxies of which our own Milky Way system is not an untypical one. Galaxies occur in a wide variety of shapes and forms. The majority exhibit extraordinary organization and pattern.

To fix ideas, let me say that a galaxy contains some ten billion or more stars; its dimension can be measured in thousands of light years. our own galaxy has a radius of 30,000 light years. Further the distance between galaxies is about 50 to 100 times their dimensions.

The second part to Hubble's discovery is that beyond the immediate neighbourhood of our own Milky Way system, the galaxies appear to be receding from us with a velocity increasing linearly with the distance. In other words, all the galaxies appear to be running away from us as though, as Eddington once said, "we were the plague spot of the universe." Hubble's law that galaxies recede from us with a velocity proportional to the distance was deduced from an examination of their spectra.

Now suppose that we take Hubble's law literally. Then it follows that a galaxy which is twice as far as another will be receding with a velocity twice that of the nearer one. Accordingly, if we could extrapolate backwards, then both galaxies would have been on top of us at a past epoch.

More generally, we may conclude that if Hubble's relation is a strict mathematical one, then all the galaxies constituting the astronomical universe should have been together at a common point at a past calculable epoch. Whether or not we are willing to extrapolate Hubble's law backward in this literal fashion, it is clear that the past epoch calculated in the manner I have indicated does provide a scale of time in which the universe must have changed substantially. Current analysis of the observations suggests that the scale of time so deduced is about seventy thousand million years.

With the time scale established, the question I stated earlier can be rephrased as follows: Have the laws of Nature been constant over periods as long as say thirty or forty billion years? And, what indeed was the universe like seventy thousand million years ago? These questions cannot be answered without some underlying theory. While there are several competing theories that are presently being considered, I shall base my remarks on the framework provided by Einstein's general theory of relativity. This theory appears to me the most reasonable.

This is clearly not the occasion to digress at this point and describe the content of the theory of relativity. Suffice it to say that it is a natural generalization of Newton's theory and a more comprehensive one. On Einstein's theory, applied to the astronomical universe in the large, it follows that at each instant the universe can be described by a scale of distance which we may call the radius of the universe. At a given epoch it measures the farthest distances from which a light signal can reach us. This radius varies with the time. Its currently estimated value is ten thousand million light years. But the most important consequence that follows from the theory is that this radius

of the universe was zero at a certain calculable past epoch some seventy thousand million years ago. In other words, the conclusion arrived at by a naive extrapolation backwards of Hubble's law, interpreted literally, is indeed a valid one. That the theory predicts such a singular origin for the universe is surprising, but it has been established rigorously, with great generality, by a young English mathematician, Roger Penrose.

And finally, it is an exact consequence of the theory that the ratio of the wavelengths of an identified line in the light of a distant galaxy to the wavelength of the same source as measured here and now is the same as the ratio of the radius of the universe now and as it was when the light was emitted by the galaxy.

During the past few years a dozen or more objects have been discovered for which the ratio of the wavelengths I mentioned is about three. Precisely what has been found is the following. In a laboratory source hydrogen emits a line with a wavelength that is about a third of the wavelength of the visible extreme violet light. But this same line emitted by the stellar object in the remote past and arriving here on earth now is actually observed in visible light. The fact that all the identifiable spectral lines in these objects are shifted by a factor of about three, means that the radius of the universe at the time light left these objects was three times smaller and the density was some twenty-seven times greater than they are now. And a careful analysis of the spectrum shows that during this span of time at any rate the laws of atomic physics have not changed to any measurable extent. To have been able to see back in time when the density of the universe was thirty times what it is now is, of course, a considerable advance. But even this ratio is very far from what it would have been if

we take the relativistic picture and go further back in time when the radius of the universe was say ten thousand million times smaller, not merely three times or a thousand times smaller. Does it appear that this extrapolation is meaningless and fanciful? But the general theory of relativity gives a theoretical meaning to such a question since a state of affairs attained by such extrapolation is predicted as an initial state for our present universe. In other words, the question is meaningful, and one can reasonably ask: Is there anything we can observe now that can be considered as the residue or the remnant of that initial singular past? But to answer this question we must take the relativistic picture seriously and determine what it has to say about that remote past. Such a determination has been made by Robert Dicke and his associates at Princeton.

Dicke calculated that at the time the radius of the universe was 10^{10} times smaller, the temperature should have been some ten thousand million degrees—in other words a veritable fireball. And as the universe expanded, radiation of this very high temperature, which would have filled the universe at that time, would be reduced. For example, its temperature would have fallen to ten thousand degrees after the first ten million years. As the universe continues to expand beyond this point, the radiation will cool adiabatically, i.e. in the same manner as gas in a chamber will cool if it is suddenly expanded. And Dicke concludes that the radiation from the original fireball must now fill the universe uniformly, but that its temperature must be very low—in fact 3° Kelvin, a temperature that is attainable in the laboratory only by liquefying helium. It corresponds to radiation at a temperature of 270° of frost. How can we detect this low temperature radiation?

It can be shown that this radiation at 270° of frost should have its maximum observable intensity at wavelength in the neighbourhood of 3 millimeters i.e. the radiation must be present in the microwave region. The remarkable fact is that radiation in these wavelengths has been detected; it comes with incredible uniformity from all directions, and they have all the properties that one might, on theoretical grounds, want to attribute to

such fossil radiation from the original fireball.

With these discoveries I have described astronomy appears to have justified the curiosity that man has felt about the origin of the universe, from the beginning of time.

As I said at the outset, man's contemplation of the astronomical universe has provided us with the one continuous thread that connects us with antiquity. And might I add now that it has also inspired in him the best.

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Are waves and particles fundamentally different?

CHHOTAN SINGH

Department of Science Education, NCERT.

AT first thought, waves seem to be different from particles in every way. A particle has a mass, can be located at a definite point, and can be imagined to have a definite size. On the other hand, a wave is massless, is necessarily spread out and has an ill defined size. Moreover, the quantities used to characterize a wave, its amplitude, wavelength and frequency—are quantities that seem to have no meaning for particles.

In spite of these obvious differences, quantum mechanics has succeeded in merging the ideas of waves and particles. To make the merger reasonable, let us consider those properties which waves and particles do have in common, even in our microscopic world. First of all, both obviously can travel from one place to another and at a definite speed. But here, too, there is difference. The speed of a wave usually depends very little on its wavelength or its amplitude. Particles on the other hand, can easily be caused to travel at different speeds dependent upon their

energy. Most important as a point of similarity, waves and particles can do the same job. Each can receive energy, carry it elsewhere, and transmit it to something else.

The merging of the ideas of waves and particles was made possible only by some changes in our views of waves and particles. Both concepts have had to yield a little in order to grow more alike. Usually, we think of a wave as vibration of something. Water-waves need water and sound waves need air. Before the theory of relativity made the idea untenable, it had naturally been assumed that light waves too need a material capable of vibrating the ether. The modern idea is that light is the wavelike propagation of electric and magnetic fields through empty space. Quantum mechanics deals with the emission, propagation and absorption of fields, associated with protons. Because of the shift of emphasis from ether to field, we gain a new perspective on waves. A wave becomes a more material thing, an entity by itself. It is still spread out, still characterized by wavelength and frequency and amplitude, but it is something by itself, not just the name given to a vibration of an underlying medium.

Quantum mechanics, then, brought with it some necessary change in our view of particle which rendered them less distinct and therefore more wavelike. The most essential feature is the non-localizability of particles. According to the uncertainty principle, which lies at the core of quantum mechanics, the location of a particle can never be precisely specified. The particle therefore loses its distinctness, becoming spreadout and a bit fuzzy, like a wave. The bigger the particle, the less important is this fuzziness, so that in the world of our senses all “particles” appear to be perfectly localized and have well defined, sharp boundaries. In the world of the very small, the fuzziness becomes all

important. The fact, that the hydrogen atom is 100,000 times larger than the proton at its centre, comes about entirely because of the non-localizability of the very light weight electron, which refuses to sit quietly alongside the proton, requiring instead all of this extra space for its domain of motion. We can say that particles are wave like because they are non-localizable. The single key equation that specifies the wave nature of a particle was first postulated by Louis de Broglie in 1924. Shortly afterwards it was incorporated into the full theory of quantum mechanics. That the proton was in some sense both wave and particle had been known since 1905. De Broglie was the first to suggest that every particle should have a wave nature. The de Broglie relation may be written

$$\lambda = \frac{h}{p}$$

This equation looks simple but has significant consequences. Here λ is wavelength, p is momentum and h is Planck's constant. Momentum is a particle like property and wavelength is obviously a wave like property. The de-Broglie equation links these two properties, and the link tying them together is Planck's constant. It is the small size of this quantum constant, h , that makes the wave properties of particles irrelevant except in the world of the very small. Thus the heart of the de-Broglie equation is Planck's constant, h . Because p is in the denominator, larger p implies smaller λ . For the enormous momentum of microscopic objects, the associated wavelength is so small that the wave property is completely unobservable. A man walking at 3 miles/hour has a wavelength of less than 10^{-33} cm. If he tries to move more slowly in order to have larger wavelength it would not help much. Progressing at one centimeter per century, he would have a wavelength of less than 10^{-21}

cm. On the other hand a single electron moving at about 3×10^8 cm/s in the hydrogen atom has a wavelength of 2×10^{-8} cm.

The most convincing direct evidence of waves comes through the phenomenon of diffraction and interference. Through these effects the wave nature of light was established beyond question early in the nineteenth century. More than a century later, the same effect proved that material particles, too, exhibit wave behaviours. Following de-Broglie's suggestion that all particles should show wave properties, G.P. Thomson, C. Davisson and L. Germer discovered diffraction and interference in electron beams (1925). Most recently neutrons have proved to be the best particles for demonstrating the phenomena of diffraction and interference. A surprising number of facts about the sub-microscopic world can be understood in terms of the wave nature of particles. Perhaps the most essential fact about a wave, as far as the world of particles is concerned, is its non-localizability. A wave can not be said to be exactly at this point or that point. At best, it is known to be in this region or that region. It can be approximately localized but the crucial distance below which it makes no sense to speak of the position of a wave is its own wavelength. The relevance of this non-localizability in the sub-microscopic world is simply that the position of a particle can never be known, even in principle, to an accuracy much greater than the wavelength of the particle. The wave nature of matter introduces an essential fuzziness into nature; the particle wavelength defines a region of uncertainty, within which the whereabouts of the particle is unknown and unknowable. One might think that this should permit us to dispense with particles altogether and say that there are only waves. This can not be done, for the particle property is still evident in process

of change, that is, in event of annihilation and creation. The birth and death of particles is particle-like occurring suddenly at one point in space and time. The life of particle between creation and annihilation is "wavelike" characterized by a wavelength and diffusedness over a region of space.

Let us apply these ideas to the size of the hydrogen atom. Here a light electron moves round a heavy proton. Between them acts an attractive electric force. According to classical physics, the electron should emit light waves, gradually lose energy and spiral down into the proton, so that the size of the atom would finally be about the size of the proton 10^{-13} cm

It is the wave nature of the electron that prevents this collapse. If the electron spiraled into the proton, it would be confined to a smaller and smaller region of space, which means that its associated wavelength would have to become smaller and smaller. According to the de-Broglie equation, smaller wavelength means larger momentum, which in turn means more energy of motion (kinetic energy). This is the crux of the matter. The wave nature of the electron means that it can be confined to a small region only if it

has a high kinetic energy. Because of the electrical attraction, the electron wants to be near the proton. But in order to have the smallest possible energy, it wants to have a very large wavelength and be spread over a large region of space. These two opposing influences—the proton's force tending to pull it in, its wave nature tending to push it out—reach a point of balance for the electron wave spread over a certain distance; this distance happens to be about 10^{-8} cm and determines the size of the atom.

So, in the world of the very small, waves and particles appear to be not merely closely related but actually one and the same thing or more accurately stated different aspects of one and the same thing. This remarkable fact was first implied by Einstein's theory of the proton in 1905, and came to be fully appreciated after the work of de Broglie, Schrodinger and others on the quantum theory twenty years later. Now we recognise the wave nature of matter as the factor that gives atoms their size, explains the uncertainty principle, elucidates the role of probability in nature and thwarts man's efforts to study the interior of elementary particles.

Example. $12956 \div 17$

$$\begin{array}{r} 17 \overline{) 12956} \quad (762 \\ \underline{119} \\ 105 \\ \underline{102} \\ 36 \\ \underline{34} \\ 2 \end{array}$$

762 R2 Ans.

A New Pattern of the Process of Division

S. G. DABHADKER, JR.

College of Education Pathri, Marathawada.

DOES the present process of division require any reform? This question raises two more questions. Why should we feel the need for reform in the present process? How should the reform be introduced?

Mathematics teachers, on the basis of their day-to-day experience of teaching division to the pupils of 3rd or 4th standard will agree with me that the present process is rather complicated—both for the teachers to teach and the pupils to learn. The reason is plain. The process requires a thorough knowledge of multiplication tables, which the pupils have learnt in the very beginning of their school life. The process is a sort of a compound of different processes such as division, multiplication, subtraction etc. This is a mixture, hard to digest easily. A concrete example will illustrate my contention.

In the above cited example the pupil is expected to rely upon the multiplication table of 17. If he knows the table well, the problem becomes easy. But unfortunately if he does not remember or is not confident about, then naturally he has to prepare the same mentally or on the paper. If he wants to avoid this task, he has to undergo some trials until he succeeds in his goal. So it is obvious that the command over multiplication table of the divisor is very essential. Furthermore when we come across a divisor having 2 digits and making a larger number than 30. (It is supposed that the tables from 2 to 30 are learnt by heart by the pupils and they retain these in their memory well), or having more than two digits, the complexity is still increased and takes different shapes. The different shapes of the complexity can be described as below:-

1. To choose suitable number of digits from the—dividend (from left to right) divisible by the divisor.
2. In absence of multiplication table of the divisor again choosing suitable number of figures from the above selected number, for the trial by the first one or two digit number of the divisor, as the case may be.
3. If the first trial succeeds so much the better, if not, a second trial with the lesser multiple is required. At times

one has to continue these trials even thrice or until he gets the correct multiple. Following example will make the situation more clear.

Example: 321405.—68

2. $5 \times 68 = 340$, Multiplication.

3. $4 \times 68 = 272$, Multiplication

4. $321 - 272 = 49$ Subtraction.

5. 494 taking down 4 from dividend.

This process is repeated till the last digit of the dividend. Thus ever changing busi-

$$\begin{array}{r}
 68 \overline{) 321405} \quad (5) \ 4 \ (8) \ 7 \ (3) \ 2 \ (7) \ 6 \\
 \underline{(3 \ 4 \ 0)} \\
 -2 \ 7 \ 2 \\
 \hline
 4 \ 9 \ 4 \\
 (5 \ 4 \ 4) \\
 \underline{-4 \ 7 \ 6} \\
 1 \ 8 \ 0 \\
 (2 \ 0 \ 4) \\
 \underline{-1 \ 3 \ 6} \\
 4 \ 4 \ 5 \\
 (4 \ 7 \ 6) \\
 \underline{-4 \ 0 \ 8} \\
 3 \ 7
 \end{array}$$

Steps followed:-

1. Selection of 321 to be divided by 68
2. Again selection of 32(of 321) to be divided by 6 (of 68)
3. First trial by 5.
4. Multiplication of 68×5
5. Second trial by 4
6. Multiplication of 68×4

The failure of trials will naturally effect the efficiency of the pupil. Further these trials make the working shabby and discourage the pupil.

Second difficulty arises when the pupil has to face multi-process working at a time. Following analysis of the working of the procedure we adopt will clarify the situation in the above example.

1. $32 \div 6 = 5$ Division

ness of process consequently must have some boring effect upon the children's mind

Even in every day life situations we see that, a person, indulged in either manual or mental labour of different processes, tries to finish one type of process at first and then take up the other type. It saves his energy and increases speed of work. It is a natural tendency.

Should we not therefore observe this natural, hence psychological tendency to the process of division? A fact that we can not deny. How to apply this tendency is the next question which remains to be answered. It may be sought in the new pattern of process that I wish to suggest.

The above cited 2 examples are solved by the new pattern below to illustrate the process.

Example 1; 12956—17

Step No 1:— Multiplication table of 17

1	2	3	4	5	6	7	8	9
17	34	51	68	85	102	119	136	153

Step No. 2:—

$$\begin{array}{r}
 \text{A. } 129 \quad 105 \quad 36 \quad (2)\text{R} \\
 \text{B} \quad 119 \quad 102 \quad 34 \\
 \rightarrow \begin{array}{|c|c|c|} \hline 17 & 34 & 51 \\ \hline \end{array} \\
 \text{Q—c7} \quad 6 \quad 2 \\
 762 \text{ R2 Ans}
 \end{array}$$

Example 2,—321405—68

Step No. 1

1	2	3	4	5	6	7	8	9
:	:	:	:	:	:	:	:	:
68	136	204	272	340	408	476	544	612

Step No. 2—A 321 494 180 445 (37)R

B 272 476 136 408

→C—Q 4 7 2 6 4726 R37 Ans.

Step No. 2:—The multiplication table of the divisor

Step No. 2:—

Column A . Figures shown in blue Ink is the dividend. Figures shown in Red pencil are the subtraction result of the previous column A & B. Red figures along with blue figure make fresh number for subtraction process

Column B: Figures chosen at a glance from the multiplication table for subtraction.

Column C : Appropriate multiples of the

divisor, when taken together is the quotient. The two steps suggested in new pattern separate the processes of multiplication and sub-

traction altogether. All the multiplication processes are completed at the outset, one after another, in serial, in the first-step. These are only eight and can easily be simplified by additions also. Their number can be reduced as per requirement of multiples in the quotient. In the second step only the subtraction process is expected. The subtraction yield is pre-suffixed to the next dividend figure for further subtractions. Selection of correct number from the step 1 table is a matter of mere glance. This process leaves no room for any sort of error liable due to lack of attention or concentration. As there is no interruption of any other process in between, one can very swiftly proceed further till the last subtraction, viz, remainder.

However, one can rightly remark that the preparation of multiplication table is a time taking process, particularly when the quotient does not require all the multiples from 2 to 9. The mental energy spent for the multiplication of these unwanted multiples is a waste. It is true but the waste can be justified as the pupil is saved from future mental strain due to trials of multiples and often change in processes. The time spent in preparing multiplication table will ease the division process and speed up the work without least fatigue or boredom. Moreover a short practice in preparing multiplication tables will make the pupil tactful and quick.

Finding the Greatest Common Divisor of two Positive Whole Numbers with the Help of Euclid's Algorithm

R.C. SHARMA,
Department of Science Education (NCERT)

V.I. BAULIN,
Unesco Consultant, Deptt. of
Science Education (NCERT)

GREATEST Common Divisor is included in every mathematics syllabus prescribed for Elementary schools and every student who completes his elementary stage knows some methods for finding the Greatest Common Divisor (G.C.D.) of two positive whole numbers.

One of these methods is (i) finding the complete set of prime factors of both the given whole numbers, (ii) finding the set of

common prime factors of these two sets i.e. the intersection of the above sets and then (iii) finding the product of these common factors. In mathematical language we can say if A denotes the set of prime factors of a positive whole number, say x, and B denotes the set of prime factors of another positive whole number, say y, then $A \cap B$ is the set of common factors of x and y.

Let us illustrate it through an example. Suppose the numbers are 30 and 21. Let us first find the prime factors of both.

$$\begin{array}{r|l} 2 & 30 \\ 3 & 15 \\ 5 & 5 \\ \hline & 1 \end{array}$$

$$\begin{array}{r|l} 3 & 21 \\ 7 & 7 \\ \hline & 1 \end{array}$$

$$A = 2, 3, 5 \quad \text{and} \quad B = 3, 7$$

$$A \cap B = 3$$

Hence the Greatest Common Divisor is 3.

Let us take another example. Suppose the numbers are 210 and 330.

$$\begin{array}{r|l} 2 & 210 \\ 3 & 105 \\ 5 & 35 \\ 7 & 7 \\ \hline & 1 \end{array}$$

$$\begin{array}{r|l} 2 & 330 \\ 3 & 165 \\ 5 & 55 \\ 11 & 11 \\ \hline & 1 \end{array}$$

$$A = 2, 3, 5, 7, \text{ and } B = 2, 3, 5, 11$$

$$A \cap B = 2, 3, 5,$$

Hence the

$$\text{G.C.D. is } = 2 \times 3 \times 5 = 30$$

We can also find the Greatest Common Divisor by (i) finding the two sets of all the divisors of the two given numbers and then (ii) finding the intersection set of these two sets and last by (iii) picking the greatest element of this set.

Suppose the numbers are 12 and 30
 Divisors of 12 are 1,2,3,4,6, and 12.
 Divisors of 30 are 1,2,3,5,6,10,15,30.

$$A \ B = 1,2,3,6$$

The greatest element of this set is 6.

Hence G.C.D. of 12 and 30 = 6.

Hence we have that G.C.D (12;30) = 6
 or the same can be written in the following way:

$$(12;30)=6$$

However, the above methods are not easy if the numbers are bigger. For example, we want to find the G.C.D. of the following numbers:

869107 and 62267

It is rather difficult to find the least prime divisor of the number 869107; since the least prime divisor is very large and it equals 877. It is the 151st prime number. In this way we should examine 150 prime numbers before we come to 151st prime number

2000 years ago Euclid suggested another method of finding the G.C.D. of two positive whole numbers. Now, in mathematics literature the process followed in this method is called Euclid's algorithm. At first we shall take arithmetic numbers to explain the Euclid's algorithm. For example; we want to find the G.C.D. of 869107 and 62267.

i.e. $(869107; 62267) = ?$

Let's divide 869107 by 62267.

We shall obtain the quotient 13 and the remainder 59636. This fact can be written as follows :

$$869107 = 62267 \times 13 + 59636$$

From here we see that any number which is divisor of numbers 869107 and 62267 must be a divisor of the remainder 59636 also, which means that it is also the common divisor of the numbers:

62267 and 59636

Hence we see that the common divisors of the numbers 86107 and 62267 are the same as for the number 62267 and 59636

which means that the G.C.D. for both the pairs will be *one and the same* or it can be written as—

$$(869107; 62267) = (62267; 59636)$$

But as far as the second pair is concerned the numbers become smaller and hence G.C.D. in the case of second pair becomes easier. Let us do the same with the second pair as we did with the numbers of the first pair.

So we divide,

62267 by 59636 and get 1 as quotient and 2631 as remainder.

$$62267 = 59636 \times 1 + 2631$$

As already explained the G.C.D. of 62267 and 59636 will be the same as the G.C.D. of 59636 and 2631.

$$(62267; 59636) = (59636; 2631)$$

Now divide 59636 by 2631.

We obtain 22 as the quotient and 1754 as the remainder. That is:

$$59636 = 2631 \times 22 + 1754.$$

Therefore,

$$(59636; 2631) = (2631; 1754)$$

Again $2631 = 1754 \times 1 + 877$ (on dividing 2631 by 1754)

$$(2631; 1754) = (1754; 877)$$

Finally dividing 1754 by 877 we obtain 2 as the quotient and 0 as the remainder, that is,

$$1754 = 877 \times 2 = 0$$

It means that number 1754 is completely divisible by 877. This can be symbolically written as follows:

$$877/1754 \text{ or } 1754, 877$$

which means is the G.C.D. of numbers 1754 and 877, that is,

$$(1754; 877) = 877.$$

So, by successively dividing the higher number by the smaller number and then each remainder by the next remainder, we shall obtain—

$$(869107; 62267) = (62267; 59636) = (59636; 2631) = (2631; 1754) = (1754; 877) = 877$$

Here 869107; 62267 are the original given numbers and 59636; 2631, 1745 and 877 are successive remainders.

Thus Euclid's algorithm lies in this successive division.

Observe that:

1. Successive division is carried on till we get zero as remainder.
2. The first remainder is less than the smaller of the two given numbers and every remainder is less than the preceding remainder or the remainders go on decreasing.
3. All the remainders are non-negative numbers i.e. greater than zero but the last remainder will be equal to zero
4. G.C.D is the last quotient in the successive division.

Let us consider the algorithm in general. Our task is to find the G.C.D. of two positive whole numbers. Let the biggest of these two numbers be 'a' and the smallest 'b' and now let us divide 'a' by 'b'. Suppose that we obtain the quotient 'q' and the remainder 'r₁'.

Then we have the following:

$$a = bq_1 + r_1 \text{ where } 0 < r_1 < b$$

If the first remainder $r_1 = 0$ then $a : b$ 'a' can be divided by 'b'

Therefore $(a; b) = b$

But if $r_1 \neq 0$ we proceed on in the same way as shown in the previous example, namely:

$$(a; b) = (b; r_1)$$

and now, we divide 'b' by r_1 . We obtain

$$b = r_1q_2 + r_2 \text{ where } 0 < r_2 < r_1$$

In case $r_2 = 0$ then b can be divided by r_1 , that is $b : r_1$

Therefore, $(b; r_1) = r_1$

But if $r_2 \neq 0$ then we come to the conclusion that $(b; r_1) = (r_1; r_2)$

Dividing r_1 by r_2 we obtain:

$$r_1 = r_2q_3 + r_3 \text{ where } 0 < r_3 < r_2$$

It can be seen that the remainder numbers in successive division are decreasing and the numbers representing these remainders remain non-negative.

$$b > r_1 > r_2 > r_3 > \dots \dots \dots 0$$

Since the magnitude of all these non-negative numbers in general being less than 'b' we go on repeating the said operation, say, 'n' times till we get the remainder 0.

It means that the remainder r_{n-2} can be completely divided (with remainder 0) by r_{n-1} . Hence, $(r_{n-2}, r_{n-1}) = r_{n-1}$

$$(a; b) = r_{n-1}$$

This method helps us to find the least common multiple if we use the following formula:

$$(a; b) = \frac{a \times b}{(a; b)}$$

where $(a; b)$ denotes the L.C.M. of two positive whole numbers a and b

Let us prove that this formula is correct.

Let us assume that M is a certain Common Multiple of numbers a and b, that is,

$$(1) \quad M = a \times k_1$$

$$M = b \times k_2$$

If D is the G.C.D. of numbers a and b, that is

$$(2) \quad a = D \times a_1$$

$$b = D \times b_1, \text{ where } (a_1; b_1) = 1$$

It results from formula (1) that

$$a \times k_1 = b \times k_2$$

Let us substitute the values of a and b from formula (2), and we obtain that:

$$D \times a_1 \times K_1 = D \times b_1 \times K_2 \text{ or } a_1 \times K_1 = b_1 \times K_2$$

In each part of the last equality we see whole numbers and that is why:

$$(a_1 \times k_1) ; b_1$$

But $(a_1; b_1) = 1$, $K_1; b_1$, that is

$$\frac{K_1 = b_1 \times t}{1} \text{ where } t \text{ is a whole number}$$

Now, let us try to substitute K_1 in formula (1)

$$M = a \times b_1 \times t;$$

$$= D \times b_1$$

$$M = \frac{a \times b}{D} \times t$$

Example

Finding the G.C.D. and the L.C.M. of two given numbers 2346 and 969.

$$(2346 ; 969) = 51$$

$$\begin{array}{r}
 969 \\
 \hline
 2 \\
 \hline
 2346 \\
 -1938 \\
 \hline
 408 \\
 \hline
 969 \\
 -816 \\
 \hline
 153 \\
 \hline
 408 \\
 -306 \\
 \hline
 102 \\
 \hline
 153 \\
 -102 \\
 \hline
 51 \\
 \hline
 102 \\
 -102 \\
 \hline
 0
 \end{array}$$

The least positive value of t will be equal to 1. Therefore, if $t=1$, the Common Factor M of numbers a and b will turn into the Least Common Multiple of these numbers.

$$\begin{aligned}
 (2346; 969) &= \frac{2346 \times 969}{51} \\
 &= 2346 \times 19 = 44574 \\
 \text{Hence: } (2346; 969) &= 51 \\
 (2346; 969) &= 44574
 \end{aligned}$$

Study Rooms for Science Subjects

W. P. KURCHANIA
Institute of Science Education,
Jabalpur

TEACHING of science has been largely hampered by the absence of science equipment in elementary schools and by the inadequate laboratories in secondary schools. Regarding teaching of science one must keep in mind that, if science is done badly, it is worse than useless.

If science has to be taught at all, no matter at what level, it has to be taught well.

Further to learn science, is to do science. This leads to the experimental method, which should be strictly adhered to in schools. The present concept of experimental work in science teaching is limited to the inclusion of a number of experiments which the pupils are expected to do during the specified period.

The Nature of Science

From educational point of view, it is very important that science teaching in schools should include activities by pupils so as to develop scientific attitude amongst them pupils and enable them to understand and develop skills associated with it. This is possible

only by having a revolution in our way of teaching and learning of science.

Even at the elementary stage, while learning science, the pupil must feel that he is participating in a creative progress. The cultural contribution of science lies in the fact that it provides participation in creative work to a large number of people. Further one must know that science is a growing subject.

This is a subject where if ten questions are answered, another hundred questions crop up for which answers have to be found; science provides us confidence that it is within our power to alter and improve, at least, our material condition. The very concept of progress lies in the awareness that man by his effort can alter his own condition and improve his lot.

Present Position

At the elementary stage general science is being taught, in our schools, mostly theoretically. There is hardly any provision for observation, demonstration or for drawing conclusions.

In secondary schools also the teaching of science, in an average class room, is by way of 'chalk and talk'. The pupils listen, write down and draw figures in their note books. But they were not provided facilities to observe those things which are taught to them. Therefore the teaching becomes verbal in nature which to some degree is rectified by introducing a few separate practical lessons. Good comprehension of knowledge and its correctness can only be achieved if a teacher's explanation is followed by demonstration of experiment students activities films, filmstrips and by the work of pupils with equipments.

In some of the schools, demonstrations during the teaching are done in specially equipped lecture rooms called science theatres; and practical work is carried out separately in laboratories. The laboratories have heavy

and expensive furniture similar to those in the universities where students, while carrying out practical work, spend the whole day in the laboratory. But in schools the pupils have to perform simple short tasks, requiring simple equipment.

Difficulties Experienced

Organization of science laboratories with big heavy tables and costly furniture along with separate science lecture theatre requires a great amount of expenditure, and most schools do not possess any laboratory in the real sense. And those, who have, are facing shortage of space due to high enrolment in science subjects. One science lecture room, originally provided in the schools, cannot cope up with the teaching of physics, chemistry and biology for all the classes from VIII to XII. The problem is likely to be more acute, when as is envisaged by the NCERT, the secondary schools will have compulsory teaching of sciences from class VI to X.

Study Rooms for Science Subjects

The problem can be solved by having theory cum practical rooms called study rooms for physics, chemistry and biology. They will house both the lecture room and the laboratory. The study rooms for physics, chemistry and biology should be equipped in such a way as to give a chance to the teacher to make the explanation of the material to be followed by the demonstration of experiments, and simple laboratory work by the pupils. These rooms may also be used for individual class and out of class practical studies of the pupils.

According to the report of the UNESCO Planning Mission on Science and Mathematics Education in Indian Schools 1954, separate teaching of theory and practice reduces the quality of knowledge. The guid-

ing principle of science education consists in combining theory and practice. In this case it is not necessary to have separate large practical room and science galleries. Instead of these, one large study room for each subject will serve both the purposes efficiently. By doing so, there will be achieved economy of funds for construction of school buildings and utilisation of existing schools areas.

Lay out of the Study Room

The number of rooms, space, general equipment (tables, chairs, almirahs, etc.), their position in the room and teaching equipment for the study rooms are determined by the content and method of subject teaching as well as by the number of pupils in the class. It is recommended that each elementary school should have a study room for general science; while in secondary schools there should be separate study rooms for physics, chemistry and biology. In large schools, where there are more than ten science sections, it is advisable to have two study rooms for each subject, and in this case these rooms may be allocated to different parts of studies, for example in case of physics—one for electricity, magnetism and sound and the other for heat, light and general physics; and so on.

A study room should be equipped in such a way as to create therein all necessary conditions for covering every type of activity by the teacher and the pupils. The study room may be about 10.35 meter long and 6.40 meter broad, with one more additional small room (3.66 by 6.40) to store teaching equipment and to carry out the preparatory work for lessons by the teacher or to verify demonstrations and experiments. In large schools the preparation cum store room may be located in between the two study rooms for each subject.

General Equipment of the Study Rooms

The study rooms may be provided with simple, cheap two-seated tables of 122 cm 52 cm size. The height of the tables may be between 2' and 2½' depending on the age group of the pupils. The top cover of the tables may be adjusted with small alterations for studies in physics, chemistry or biology. For physics each table may be provided with A.C. mains and 6 volts plug either from a rectifier or from accumulators. Chemistry tables will have water supply tap as well as a drainage sink, gas burner or other heating appliances. The pupil's tables be so placed in rooms as to have light from the left side with all the pupils facing the teacher and working in a comfortable pose.

On the side away from windows, suitable almirahs or cupboards may be placed to house equipments and accessories commonly used in the class.

In the front of the class, a platform about 15 cm high is suitable. It will be the working place of the teacher. A demonstration table with additional equipment, a blackboard with some devices, a stand for charts and diagrams may be placed on the platform so that the pupils may clearly observe the demonstrations done by the teacher. The size of the demonstration table may be about 244 cm x 90 x 88 cm and it should be made heavy and steady. The surface of the table is to be covered with linoleum or coated with water-proof and acid-proof paint. It should contain drawers and shelves in order to store those things which are in frequent use by the teacher during the lessons. This table should be provided with sockets for D.C. and A.C. electricity, water and gas. If electricity is not available to the school, electrical appliances should be worked by accumulators which may be housed in a special place in one side of the table. In case water supply is not available, it is advisable to provide

water tanks some where on a higher level and water may be led through the pipes to the demonstration table, that has sinks for draining it. If there is no gas supply in the school, it is necessary to have suitable heating devices.

A blackboard of size 3.66 x 1 cm is suitable. It need not be painted black. Green or brown boards are better suited and are not hard to the eyes of the pupils. These boards may be made of linoleum or hard board painted green or brown. They should be provided with a shelf and a box for chalk and duster, and a drawing instrument set which are often used in a physics study room.

It is expedient to fix above the blackboard simple devices for fastening diagrams, maps, charts and other teaching aids. A screen is fixed above these to show drawings, diagrams, filmstrips and films. If projection is to be done from the demonstration table itself, the screen should be inclined over and above the blackboard. If the projection is to be done from the opposite side of the class, it can be of rolled type.

The study rooms should be provided with paper or cloth curtains to darken the rooms when film strip projector, slide projector, epidiascope, etc. are used. Additional equipment required in the teaching work may also be fixed at suitable points near the dias. A few pictures of scientists on walls and show-boards depicting products of science clubs, etc. greatly enhances the educative value of the study rooms.

Besides, each study room will have its own speciality. Chemistry study room will have a fume cupboard and a cupboard for permanent set of solutions and solids which are frequently required by the teacher and are necessary for solving experimental problems. Biology study room will have cabinet with dark and light chambers. There should also be a zoo corner for biology teaching.

For this purpose it is necessary to provide cages for birds and animals, terraria and acquire a plot of land in the shade for growing plants and all other necessary things for carrying out experiments and observations of living organisms.

General Get-up

The painting of walls and furniture also needs consideration. It is necessary to select those colours which absorb light in small quantities and at the same time have poor reflection, that is, it should not be tiring to the eyes of the pupils. In this connection, the UNESCO Planning Mission 1964 has recommended that the biology table tops should be painted dark green while the understructure of tables and planks in the middle of the walls light green; the tables in the physics and chemistry study rooms should be painted brown and light brown and plants in the middle of walls of cream or deep

cream. The ceiling and the upper parts of the walls should be whitewashed. There is still a need of research work in this direction in our schools.

Merits of Study Room

Such an organisation of teaching in which both theory and practical work are done in the same room has been proved better, where it has been tried. Besides being economical and sound on pedagogical grounds, it is more useful on hygienic grounds. In the traditional laboratories when six to eight pupils stand around a high table doing practical work, majority of them work in unfavourable conditions regarding lighting and their position is such that the teacher experiences difficulty in looking after and checking their work. In the proposed study room the teacher has better command over the class and is in a better position to give guidance to pupils.

ELEMENTS OF PROBABILITY

A Textbook For Secondary Schools

By S.K. Gupta

Crown Quarto, pp. vii+88, 1968

Rs. 1.35

Following the more modern approach based on the concept of a 'Sample Space,' this book is almost the first attempt to present elements of the theory of probability for secondary schools students in India—the theory that finds an important place in all new programmes of school mathematics.

Enquiries

The Business Manager
Business Wing
Publication Unit
N C E R T
71/1 Najafgarh Road,
New Delhi - 15

Main Principles of the Biology syllabus for the middle and senior high school

S. DORAISWAMI

Department of Science Education, NCERT,
New Delhi

V.M. GALUSHIN

G.R. MEYER

Unesco Science Consultants,
Department of Science Education, NCERT

IN the task of implementing the Secondary School Science Teaching Project the Biology group of the Department of Science Education of the N.C.E.R.T. and the UNESCO team of experts have prepared a new syllabus in biology. It is mainly based on the idea that biology (along with chemistry physics and mathematics) should be taught as a compulsory and separate subject for all the students of the middle and the senior high school classes in the secondary schools.

At present in Delhi schools science is taught as general science upto VIII class and then pupils read science as elective subjects from class IX to class XI But from the year 1968-

1969, all schools in Delhi have adopted the teaching of biology as a separate subject from cl. VI onwards. This follows a trial period of 3 years in which the subjects were taught as separate disciplines in about 30 schools as part of the experimental project undertaken by the NCERT, in collaboration with a team of experts from the Unesco.

The main objectives of the Biology course under this project can be stated as follows:

1. To give a comprehensive and systematic knowledge of the world of living things and of man, on a scientific basis;
2. To discover the basic principles of modern biology.

These main goals have in the long run determined the content and structure of the biology syllabus. It was found that the optimum structure in accordance with the basic objectives of the course is to combine naturally:

- (a) a systematic study of plants, animals and man, (at the middle stage;) and
- (b) consideration of the unifying principles and concepts of biology (in the senior high school stage).

Generally the construction of the biology course for the secondary school is based on a flexible line of development.

Teaching time

In order to study properly the topics suggested in the Biology Course the lessons have to be covered in 540 periods during the six years of the school, taking three periods per week during each school year. Actually a lesser number of periods per year is suggested in this syllabus. This allows teachers some freedom to use about five periods per year for revision or tests or other adjustments to the programme.

Characteristic features of the Biology Course for the middle schools

The syllabus for the middle stages is drawn up in order to give the pupils a basic knowledge of the living world surrounding them. They need this knowledge in their everyday life and in their work in different spheres of occupation especially in agriculture, health and medical services. It is for this that the relationships of biology to agriculture, human nutrition, health, medicine, problems of family planning and economy are stressed. According to this objective the course is intended to give the pupils of the middle schools classes a thorough understanding of the following aspects of biology:

1. Familiarity with the most common, important and interesting groups of plants and animals in their environment. They must know something of the diversity of plants and animals. They should know their main characteristics, modes of life and their importance.
2. There should be a good understanding of the basic structure and knowledge of the life activities of plants, animals and of man.
3. The pupils should understand the main trends in the evolution of the organisms from the simple to complex. The basic idea of evolution must be referred to even while studying the structure and activities of plants and animals. The concept of adaptation should be introduced wherever possible. The need for correct management of plant and animal resources and conservation should be a continuing theme. Problems of controlling harmful animals and plants should also be considered.
4. The course should provide a general picture of the living world and man's place in it. It should also bring out

the links between man, the plant and the animal world. At the same time we should clearly understand that the principle of linear construction has some advantages and some disadvantages. To strictly adhere to a linear development might lead to the danger of following a very traditional approach to the biology course. It can turn into an old-fashioned description of plants and animals and their diversity as a series of isolated facts. To avoid this danger the syllabus and textbooks have enough material on the ecology, the importance and utility of plants and animals, and also a comprehensive understanding of some basic principles of occurrence and development of living things. Great care should be taken in the training of teachers to ensure that the diversity of plants and animals is taught to emphasise an environmental approach to this part of the whole biology course.

The second probable defect of this structure is the impossibility of achieving all the objectives till the end of the total course. This problem is partly solved in the revised syllabus, by including a section on "Man and his environment" which brings together the main ideas of the whole biology course for the middle stage and stresses the significance of these ideas in the day-to-day life of the pupils. This section also gives some understanding of relationships between the living and the non-living world; a simple analysis of the biological events occurring in agricultural fields and a general consideration of the way man should learn to control, manage and conserve the resources of his environment. In short, this section is a conclusion of the middle school biology, and at the same time it acts as a bridge to the senior high school biology.

Even as these measures remove the effect of the drawback of this structure its merits become more significant. The biology course allows pupils to get a much more systematised and logical organised knowledge of the living things serving man in his everyday life. The principle of a sequential study of plant and animal worlds and man's body is most comprehensive for pupils of the age 12-14 years (classes 6 to 8).

To this end the method of teaching should emphasise experimental and practical work in classes and observations in nature through field excursions. Wherever possible the topic should be introduced in the form of problems and pupils should be helped to find solution to these problems. The whole programme therefore is based on activity by the pupils as well as the teacher.

Characteristic features of the Biology Course in senior high school

The main aim of this course is to enable pupils to develop an understanding of the basic laws and regularities governing the structure, origin, occurrence and development of living things. The course is presented as a unified programme explaining the main principles of modern biology. The topics are based on the material of the preceding portions in biology covered in the middle school stage (Botany, Zoology, Human Anatomy and Physiology), summing up the knowledge obtained by pupils earlier and giving them a deeper understanding of the basic principles. At the same time the course includes fresh topics chosen to explain the life processes in the organism. This portion of the Biology Course is being referred to as "General Biology" for want of any other way of describing it. The following are the most important topics dealt with;

1. Fundamentals of molecular biology.

2. Genetics.
3. Evolution.
4. Fundamentals of ecology; and
5. Conservations of nature

The course of General Biology covered in the senior high school has three principal objectives:

1. To present in a comprehensible form and on the level of modern science, systematised ideas of the world of living things.
2. To reveal the basic laws and regularities in the structure, function and development of living matter at various levels of biological organization.
3. To give an understanding of the methods used by biologists in investigation problems.

The structure of this syllabus allows the pupils to understand the unity and coherence of biology as a discipline. At the same time it provides a systematic review of the world of living things. This course of General Biology is built on the basis of the following few principles.

1. Modern scientific ideas at the levels of biological organisation of living substance, mentioned below:
 - (i) Molecules and cells.
 - (ii) Organisms
 - (iii) Populations and natural communities.
2. The educational principle of gradual elaboration of the material studied.

The suggested syllabus retains the distribution of the material according to the three basic levels of biological organization. However, the sequence of their study emphasises the educational rather than the biological criteria. Logically it will be more appropriate to start a course for modern Biology with a study of cells, proceeding then to organisms and finally to populations. But the study of cells is difficult at this stage and

requires a good understanding of physics, and chemistry. Because of this study of the cells has been included later in the programme instead of at the very beginning. It is felt that this departure from the logical sequence of the discipline will be more than compensated by the educational advantage gained. It leaves the most difficult part of the course for the more senior classes where the pupils who have gained a good knowledge of physics and chemistry.

This course includes discussion of some problems and topics already dealt within the programme for the middle school. However, this is aimed exclusively at achieving a more profound understanding of the basic principle.

For instance, the structure of the cell has been introduced in a simple way in Part I of the Biology Course. In part V, however, the structure and function of the cells are studied in a new level. There are now explained in terms of molecular biology. As another example, the organ systems of vertebrates, including man, were discussed in Parts II and III. Now in Part IV they are studied in a different way. The structure and function of selected systems are taught in a comparative basis, to enable pupils to understand the underlying unity and gradual development of the animal world and provide evidence that evolution has in fact occurred.

Some organ systems are studied in detail, enabling the pupils to have an understanding of the frontiers of knowledge. Topics such as the nature of the nerve impulse and chemical control of reproduction for example are being studied intensively by research workers. A modern course in science should take students to the point where they can appreciate these topics.

One of the key ideas underlying the syllabus is the close relationship between the basic principles of biology and the contemporary

needs and requirements of economy, agriculture and medicine. It is with this aim in view that the topic 'Conservation of Nature' has been included. This topic forms an important section of the course of biology. It helps in the analysis of man's relationships with nature as well as a consideration of the ways of maintaining our environment for the future. The normal balance in nature and consequently the guarantee that life will continue to exist on the earth depends on our understanding of this principle.

In each section of the course the part played by biology in human welfare would be emphasised. Special attention is given to the role of biology in the future of man; its importance in producing an abundance of food and raw materials; its role in putting man into outer space; its conquest of diseases and old age, and its role in the understanding of ourselves and our total environment.

The syllabus also envisages preparation of instructional materials which would take into consideration both modern methods of teaching and the rapid expansion of scientific knowledge.

Use would be made of demonstrations, experiments, individual observations of nature, readings from scientific and popular books and organized field studies. The main educational aim of this general biology course is to give pupils a deep understanding of the process of scientific enquiry and development of science. It should enable the pupils to adopt creatively modern ideas of biology and encourage them to apply this knowledge and understanding to the solution of daily problems.

Conclusion

The total course in biology beyond the primary school forms a continuous and coherent programme. It combines a sys-

tematic study of plants, animals and man made in the middle school stage with a consideration of the general concepts and unifying principles treated at the high school stage.

educational objectives of biology is to help the teacher to develop the pupil's independent thinking, to teach him to realise the essence of the process of scientific development, to prepare him to adopt creatively the new ideas which would be given to the world by the science of biology in the near future.

At least one of the generally accepted

APPENDIX I

Main topics of the Biology course for the Secondary Schools (Classes 6—11 in Delhi Schools)

Middle stage; 270 periods; 3 periods per week

Part I (class 6)	85 periods
A. Botany	85 periods
Part II (class 7)	85 periods
B. Zoology	85 periods
Part III (Class 8)	85 periods
C. Human physiology	68 periods
D. Man and his environment	17 periods

Higher stage: 270 periods; 3 periods per week

Part IV (Class 9)	85 periods
A. Introduction, the basic principle of the structure and process of life	2 periods
B. The organism	30 periods
C. Natural communities	53 periods
Part V (Class 10)	85 periods
D. The molecule and the cell	85 periods
Part VII (Class 11)	85 periods
E. Fundamentals of genetics and selection	43 periods
F. Evolution	40 periods

Duration and Content of Pre-Medical Education

V. RAMALINGASWAMI

All India Institute of Medical Sciences
New Delhi

WHAT is pre-medical education? Etymologically, it could mean all the education or the lack of it that preceded the arrival of a student at the portals of a college of medicine. Practically, however, it refers to that phase of education prior to regular medical studies in human anatomy and physiology which includes the study of natural sciences, humanities and behavioural sciences and which is designed to provide a comprehensive general education. It aims at a balanced education in humanistic and scientific studies in order to generate continued interest in the phenomena of living organisms (W.H.O. 1961). Elective studies in depth in some selected areas and introduction to the experimental method are additional features of the pre-medical education programme in some parts of the world.

There is at present a conflicting variety of patterns of school and higher education in India (Report of the Education Commission, 1966). It has been aptly remarked that the pre-school stage is characterised by no formal education and no work, the school stage by full-time work and no education. Our present system of secondary school education demands that our boys and girls must decide their future careers at IX class level at the age of 13 or 14. Once this is done, they enter, in almost all instances, an irrevocable path of differentiation. For those who wish to proceed to medical studies, the emphasis on the pre-medical subjects physics, chemistry and biology is progressively intensified during the remaining years of school and the pre-medical period at college resulting in a 'virtual arrest' of development in language, literature, arts, history and even mathematics. The courses are largely directed towards imparting a certain quantum of memorised knowledge with the main object of passing a stereo-typed examination. There is an early restriction of thought and action and instruction proceeds along narrow grooves with set courses largely devoid of active learning opportunities (Ramalingaswami 1965). As Dr. Kothari in his introduction to the Education Commission Report has stated, "the single most important thing needed now is to get out of the rigidity of the present system."

What is formally designated as pre-medical course consists of one or two years of preparation in which physics, chemistry, biology and one or two languages constitute the essential subjects of study. The one year course is taken after passing through a Higher Secondary or a Pre-University Course and the two-year course is taken after matriculation.

Paper read before the All India Medical Education conference held in New Delhi in January 1969.

The conference should take note at this point of the far-reaching recommendations made by the Education Commission popularly known as the Kothari Commission. The 10 year period of undifferentiated general school education proposed by the Commission without any specialisation so that no streaming occurs in schools up to Class X, together with the experiments that are being conducted by the National Council of Educational Research and Training on the teaching of physics, chemistry, mathematics and biology as parts of the total science course from the middle school onwards, are encouraging trends in the horizon of pre-medical education. The new Middle School syllabus in physics for example is designed to provide a clear understanding of basic theories with the help of simple experiments performed by the students themselves. In biology, the middle school course gives an understanding of the structure and function of plants and animals, acquaints the pupils with the world of living things which surrounds them, enables them to discover the main laws governing the regulatory processes, gives them an understanding of the nature of science and the way scientists work, and creates in them a scientific attitude to problems of every day life. The emphasis is on relationships of living things to their environment and on their importance to man. Links with agriculture, human nutrition, health, medicine and economy are stressed. The course thus presents a programme of environmental biology and is not taught as a formal course of morphology and taxonomy of plants and animals. One can only hope that the recommendations of the Education Commission with regard to general school education together with these experiments on the teaching of science at school would be implemented on a wide scale throughout the country.

These developments would exert a profound influence on the quality of entrants to the pre-medical courses.

Objectives of Pre-medical Education

The objectives of Pre-medical education cannot be divorced from those of medical education itself. Indeed the formal medical course of 4½ years together with the year of internship is but one segment of a much longer process; much of vital importance takes place before and much after (Tuner 1963). The emphasis should be on a continuous stretch of the student's mind; the major discontinuity and the wide gap that now exists between pre-medical and medical education must be bridged and every opportunity should be seized to integrate better the teaching at these two stages in the continuing process of medical education.

The conference has to debate and decide what is the kind of a physician that they would like to be trained in India in the present context, for on this will depend, to a large extent, the objectives of pre-medical education. Do we need to train a prototype of a physician who would be mainly a clinician in the style of Osler, well versed in the art of medicine but who may not necessarily meet the criteria for a scientist? Do we need a 'scientist-physician', the new type of academic physician that emerged as a result of the explosion of scientific knowledge that took place following the Second World War? Do we need a 'primary physician', a type of 'social scientist physician' who was the hero at the time of the Third World Conference on Medical Education in 1966, whose essential task was to improve the delivery of medical care; or else, do we need on this day, the 4th January, 1969, "a physical-scientist-physician" in line with the great contemporary advances in physical sciences as applied to medicine (Funkenstein, 1968)?

Or a combination of all these types in one? We can be certain that this is not the end of evolution of the physician prototype as the remaining part of the 20th century unfolds itself. The type of physician that a society demands at any particular time depends on its living standards, its stage of scientific and technological development, its consciousness of health. There has been much discussion in the past on the objectives of medical education; there will continue to be more discussion in future.

But whatever objectives are envisaged for medical education, there would perhaps be no disagreement, with the objectives of pre-medical education when they are stated in general terms to provide a basic core of knowledge in physical and biological sciences in the context of a broad liberal education.

The courses must introduce the student to *processes* rather than to an array of assorted facts. The development of skills in applying the scientific method of capacity to analyse and interpret data and finally to synthesise the bits of evidence into a meaningful whole should be the main objectives (W.H.O. 1964).

Duration of Pre-medical Education

Formal pre-medical education at the present time occupies one year of study after a candidate has gone through the Higher Secondary or the Pre-University Course. There is, I believe, much repetition in the courses offered for the higher secondary and pre-medical studies and no sequential development of a student's intellectual processes. The mere addition of months or years to a course does not make it any better. The notion that the longer one stayed at school the better one gained in knowledge and maturity is now out-moded. The provision of appropriate opportunities and experience is of the essence. There is indeed a serious suggestion made by Machlup (1962) in the

U.S.A. that school education which until now required 12 years in that country could be reduced to 9 or 10 years with attainment of the same educational objectives by acceleration of the learning process. A similar recommendation has been made by the Education Commission whose revised proposals now contemplate the coverage of the hitherto eleven years school course in ten years time. If widely accepted, the commissions proposals would provide two years of continuous and integrated study of pre-medical sciences after 10 years of school and this should result in a better and a more closely integrated pre-medical education.

Content of Pre-medical Education

The basic education of a physician is essentially the same as that of any other learned profession. There is, therefore, no important differences between the standard required of medical student and those studying other subjects at the university. As the Pickering Committee on the new medical school in Nottingham University observes, a medical student is a science student with the difference that the material content of his study is oriented to man and his diseases (Report of the Medical School Advisory Committee, 1965).

A curriculum is no better than its teachers and the manner in which the course is given is more important than the course itself. In giving an outline of the content of pre-medical course, I would like to emphasize that this is not meant to be universally applicable but is just one example. The basis of medicine lies in *biology* and as the WHO Expert Committee on Professional and Technical Education of Medical and Auxiliary Personnel has observed in 1964, biology should be taught as a dynamic, multilateral and comparative science ranging from the molecular level to that of individual human beings, communities and populations. Today, bio-

logy is still taught in our pre-medical courses for the most parts along phylogenetic and taxonomic lines and on dead specimens preserved in museum jars. The teaching of systematic zoology and botany should be limited to that necessary to establish the place in nature of man and of those animals and plants of importance in disease or in medical research. Basic concepts of the structure and function of living organisms, embryogenesis, evolution, comparative anatomy and physical anthropology, cytology, fertilization, growth development and ageing should figure prominently in the course. The teaching of biology should continue throughout the preclinical and clinical periods of instruction as well.

Physics and mathematics are closely allied to one another. Their essential functions is to facilitate precise and accurate habits of thinking. Modern developments have clearly brought out the importance of the physician and the physicist working together. The use of X-ray diffraction has helped considerably in revealing the structure and configuration of large molecules. Recent advances in physics have opened up a new range of applications to medicine. Of the various conventional divisions of physics, a study of electrical phenomena, mechanics, hydrodynamics, thermodynamics, optics, nuclear physics and radioactivity is of particular importance. The nature and biological effects of ionising radiations carry several implications and will be a recurring theme throughout the medical course but its roots must be sown at the level of the pre-medical education.

Chemistry is an experimental science and must be treated as such. Students must be encouraged to make observations on problems rather than observe set demonstrations. Chemistry is a rapidly expanding field and the question often arises how much chemistry

in the pre-medical courses. Of the various subdivisions of chemistry, physical and organic chemistry are of outstanding importance for a proper appreciation of biological and pathological chemistry.

The early specialization which is demanded today in secondary education together with the tremendous impact that science is making on society has lead to serious inroads into the time available for a liberal education in *humanities and behavioural sciences*. In the setting of the U.S., it has been stated that the liberal arts tradition is dead or dying Barzun (1964) says that the preprofessional college courses are being invaded, not to say dispossessed, by the advance agents of the professions. The cry is heard everywhere that talent must be developed into competence as early as possible. As Barzun says, the speed of events in this sphere is so great that to resist this trend would be like attempting to sweep back the ocean.

It is just as well to remind ourselves that medicine is practised not in a world bounded by science alone but in one in which humanistic and social influences are playing an important influence both upon the physician and his patient. The place of language and literature has been discussed this morning. The study of humanities ought to provide the student with an intelligent understanding of his past and of the great ideas that have moulded civilisations. Experimental psychology, cognitive psychology, social psychology, social anthropology and psychodynamics are all intimately related to human behaviour. Some acquaintance with these subjects is desirable although obviously none can be taught in any depth. There is a steadily growing appreciation of the importance of psychology and social factors in disease and illness, and the need for a systematic education of the physician in this area is widely felt. The process of educa-

tion in this sphere should begin in the pre-medical period and continue throughout the medical course.

Conclusion

The main purpose of pre-medical edu-

cation is to develop a love of learning and a discipline of the mind. Its content is embedded in the framework of natural sciences, humanities and social sciences.

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Role of Basic Researches in Biology and New Trends in Biology Teaching

B. M. JOHRI AND S. L. TANDON

Department of Botany, University of Delhi

THE prosperity and strength of a country are dependent on the level of scientific achievement, and on its capacity to make use of that knowledge to serve practical ends. The major criterion for scientific advancement is generally accepted to be creativity. The most obvious avenue for creative effort is the enlargement of knowledge through research. The 20th century, especially the last 30 years, has seen rapid advances in research in all disciplines of science particularly life sciences. It is said that man has learnt more during the last three decades about the essential life processes than during all the preceding centuries. If this progress is to be maintained and accelerated, we require better trained scientists. One of the ways to achieve this is to give utmost attention to the teaching of science at the school level. The role of basic researches and

problems of biology teaching in schools are discussed in the following pages.

Role of Basic Researches

The teaching of biology should be based on basic researches and the teaching methods as well as the revision of curriculum should proceed hand in hand with the advancement of knowledge. One of the important aspects of basic researches in biology concerns the understanding of fundamental principles governing life processes at organismal, organ and tissue, cellular and subcellular levels. There is a general feeling that the biology taught to the school students does not adequately reflect the current stage of knowledge. The change of the curriculum, therefore becomes inevitable. The existing courses do not emphasize the major concepts but are mainly concerned with the details of nomenclature, classification and morphological description. In the development of new curricula and the keeping of existing ones up to date, there is a need for identifying the organisms which are most suitable for teaching biology in any particular geographical region. The following may be useful in finding organisms suitable for teaching biology in a given region.

- (a) Publications made by Teacher Associations.
- (b) Publications from biological research units organised by government departments.
- (c) Resource newsletters from the universities.
- (d) Newsletters or journals published by science associations including Asian Association for Biology Education (AABE)
- (e) The offering of incentives to teachers for experimenting on the problem of finding suitable organisms. These incentives may be in the form of salary

increments, merit awards, etc.

- (f) Using the examination system, to give credit to those who have worked on the problem of finding suitable local organisms.
- (g) In-service training could be utilised for developing experimental work for the finding of suitable local organisms.

The problem of supply of suitable organisms for class use frequently arises. This can be achieved, to a limited extent, by taking help from the universities and research institutions. It would be ideal if the teacher, with the help of students and laboratory staff, could collect the materials from local sources. The commercial supplies should be utilised where a particular material needed for class work may not be available locally.

The transmission of findings of basic researches in an understandable form to the students is very important. This cannot be achieved without the close cooperation of the university and the government research staff. To accommodate the results of latest findings, it would be imperative that there is a continuous curriculum revision. The revision of curriculum should be entrusted to a committee consisting of representatives from the universities and schools. The role and impact of basic researches should be communicated to the school teachers through publications especially designed for this purpose. To some extent, this is being done through a journal like, the *School Science* published by the National Council of Educational Research and Training, New Delhi. School science journals should, thus, form an important channel for the transmission of modern knowledge gained through recent researches. Other similar means of communicating the information would be news-letters and pamphlets from Science Education Centres, Science

Associations, AABE, and commercial publishers. It would be proper for the government organisation to stimulate private competent individuals to publish monographs on recent researches in biology. Suitable textbooks should also be written and revised frequently in view of the new developments. Since publication of textbooks in India is not under the direct control of the government, only such of the textbooks which contain up-to-date information should be recommended for use by the students. In India the textbooks are generally recommended by the State Departments of Education, or the Boards of Secondary Education of the State. This is usually done by the Textbook Committee, or the Committee of Courses of the subject concerned.

Another method of transmitting the findings of basic researches to the school teachers is by arranging for their in-service training courses. This is being done in India through the organisation of Summer Institutes during the last six years. The Summer Institutes aim at reviewing basic principles in the light of recent advancements. Through this programme the schools are encouraged to adopt new curricula and courses aimed at meeting present-day needs. Short duration seminars and study circle meetings can also help in this direction. These may be organised by Science Associations and Scientific Institutions of higher learning. The Department of Education of some of the States in India organises such short duration courses for the benefit of its school teachers. The one-year teacher education course (Bachelor of Education) after M.Sc. is a pre-requisite for recruitment as a science teacher for teaching higher secondary classes. This course includes a study

* In India, of the 11 year school system, Classes IX, X and XI are regarded as higher secondary classes. Such schools are designated secondary or higher secondary schools.

of the principles of education, educational psychology, school management, history of education, and methodology for teaching the subject of specialization (biology). During this training the would-be school teachers should be given instruction in the methodology of teaching the more important modern topics.

The findings of basic researches can also be communicated through films especially made for this purpose. The Indian Society of Genetics and Plant Breeding, in 1965, presented 'The Secret of Life' in the form of a 'Ballet' which has since been filmed. This Ballet seeks, through the medium of music, dance and mime to interpret the reality of the concepts which lie at the frontiers of modern science. The scene of the action is inside the cell. The dancers, at first representing parts of the basic atoms, show how the first organic molecules were developed from inorganic molecules. Later, they demonstrate the structure of deoxyribose nucleic acid by portraying the arrangement of its nitrogenous bases and, next, they indicate in mime, how the genetic code operates in building proteins with amino acids. Finally the ballet turns to the ancient symbol of creation, the Dances of 'Shiva'—the humble recognition of the fact that science has not yet solved the ultimate mystery of life. The most recent subject of DNA and its importance has thus been presented in a form which can be understood not only by students of science, but even by laymen. More films of this kind should be made in area of biology and related sciences where the school teachers might not be familiar with modern concepts.

The promotion of basic research in schools although desirable, poses certain difficulties on account of shortage of time and finances in most school situations. There is no doubt that the teacher who undertakes even a small piece of research views the subject

in a more lively way. Teachers who are interested in conducting research in their spare time should be encouraged to do so and facilities should be provided at the universities and government institutions. To initiate school teachers into a research programme, short time research projects should be arranged at the Summer Institutes. Research for higher secondary school students is also to be encouraged through science clubs, and giving them open-ended laboratory exercises. It may be pertinent to mention here that a group of students selected after Higher Secondary, on the basis of a competitive test, are given training in methodology of research at the Summer Schools. In order to identify promising students in science and provide them necessary encouragement for pursuing higher studies in basic sciences, the National Council of Educational Research and Training in India has been operating a scheme of Science Talent Search since 1963. Under this scheme a number of scholarships are awarded to meritorious students who possess an aptitude for studying science. The scholarship continues till the student gets his doctorate in the subject of his specialisation. The selection is based on a science aptitude test of which the submission of a project report forms an integral part. This report is based on the fact that the student should have considerable creative thinking, experimental work, critical observation, and comprehensive expression. These scholarship awardees are given short research projects in the modern fields of biology at specially organised Summer Schools during vacation period.

The objective of teaching is to inculcate in the students a habit of deep thinking, appraisal of scientific facts, keeping in view the background information, present status of knowledge, future trends, and unsolved problems.

The role of basic researches in solving some of the human problems should also

be taught. This may be illustrated with the help of a few examples. The study of evolution will acquire more meaning if the students were told about Charles Darwin's outlook and the circumstances which led him to formulate the concept of Natural Selection. The concept itself is important no doubt but much more important is the impact that this concept had on human thinking. The publication of 'Origin of Species' was a great event of the nineteenth century and led to the decline of the influence of the church in human affairs. One of the best evidences which can be given in favour of the idea of evolution is from the artificial synthesis of a naturally existing forms. An example showing the identical nature of the artificially synthesized and the naturally-occurring form would be a very convincing evidence for evolution having taken place.

We may select the 'cell' as the second example. The original concept of cell, as put forward by Robert Hooke, envisaged that these were compartment-like structures as seen in a slice of cork. The word, cell, has since been retained but the meaning has undergone much change in the light of basic researches made possible by the improvement in light microscope and invention of electron microscope. The development of our knowledge of the structure and function of the nucleus has been most spectacular.

Beginning with the discovery of the nucleus by Robert Brown we have moved very far to the structure of DNA and its role in heredity. A number of geneticists and biochemists have been awarded Nobel Prize for their brilliant researches in this field.

Other areas where much new knowledge has resulted are those of physiology and ecology. The two are so closely related to each other that they cannot be taught separately. One of the most important

aspects which has drawn world-wide attention is the food problem. This is essentially due to the 'population explosion'. The International Biological Programme (IBP) is responsible for a number of research projects in various parts of the world, especially ecological research concerning productivity.

The basic researches mentioned above, and numerous others, should indeed form a basis of high or higher secondary school biology teaching.

Discovery Method

The method of instruction is equally important as imparting up to date information.

The present method of teaching biology is mostly by deductive exposition, that is, handing out of the factual material directly by the teacher to the students. It is now strongly felt that a better method of teaching would be that the students would work for themselves to be the inquirers and the recorders of actual experiences instead of being the recipients of deductive lessons. In fact, the major fault in the teaching of biology and even other sciences, particularly at the school level, has been the emphasis on authoritative content rather than on investigative processes of science. The core of the scientist's way of life is inquiry. The art of investigation requires brushes and tools of a special kind. Just as a good painter learns to paint by painting, the student of science can learn better by actual investigation. The discovery or the inductive method of teaching, aims at training pupils to think, to handle ideas themselves rather than memorize the factual material given by the teacher or gathered from the textbooks. In other words, this is a method by which the pupils are encouraged to find the facts of science by themselves and there is an opportunity for potential scientists to exercise their ingenuities. Instruction should

especially prove useful in the teaching of biology where we are dealing with living material. With the present method of teaching, students seem well-versed in the factual material of biology although unable to relate this knowledge in a meaningful way. They are often completely helpless when it comes to setting up even the simplest kind of research project on their own. Even the graduate students who have been declared as brilliant on the basis of their examination results are often found lacking in the understanding of the basic concepts of biology. This is mainly due to the defective way in which biology was taught to them. The facts we discover for ourselves are better understood and remembered than those we get from others. This principle seems particularly appropriate in the teaching of science subjects where the great achievements take the form of discoveries. The scientist works in order to discover and he continues to work so long as he has a chance to discover. There is no reason as to why any serious-minded student of science should be denied the same motivation. It may, however, be made clear that the teaching of biology by the inductive method does not mean that the student is to discover the whole of biology or even any appreciable part of it by himself. Any one conversant with the history of biology, or for that reason any science, is aware that it takes generations of brilliant scientists to discover what is often referred to as a simple scientific fact. This can be easily exemplified if we trace the development of our knowledge which finally led to the discovery of the 'circulation of blood' but which is now considered to be a simple fact. The various disciplines in biology constitute a vast accumulation of the discoveries of a great many men. It must be transmitted either in the form of books, lectures, demonstrations or laboratory practi-

cals, or in the form of investigatory exercises requiring original thinking. How much of biology is to be taught, how much is simply to be made available in recorded form, and how much is to be left for rediscovery are questions concerning the available time and energy and interest of teachers and students.

For the successful implementation of the discovery approach as a method of teaching, skilful questioning is essential. The teacher considering the background of his pupils may set up a problem. Through skilful questioning the teacher draws forth from students their own observations and conclusions. In the classical method of teaching biology, when the students are doing the experiment or watching the demonstration, they already know the results beforehand. Hence, much of the stimulus in learning is lost. For the successful operation of the discovery method, the teacher may have to build up the necessary background of his class in order that his pupils may carry out a proper investigation of a problem. Again, the background to be provided depends on the calibre of his class. It is very important that the teacher sets up a problem which is well within the general calibre of the group he is dealing with.

Curriculum

A proper school environment is essential in order that the students get the maximum opportunity to learn as to how to investigate. A broad approach to the curriculum is necessary for creating a more adequate environment for investigation. The revision of a biology syllabus poses a number of problems. A single syllabus with specific topics may not be liked by all the school teachers who may like to approach from an independent standpoint of their interest and background training. There is a strong feeling

that the biological knowledge for the introductory courses should be presented in such a way that one may realise the integrity of the unity of the biological system. This would imply that the syllabus at the school level should be for biology and not for botany and zoology. In order to have a correct view of biology, we can no longer be satisfied without incorporating recent progress in the fields like molecular and space biology into the traditional framework of the presentation of knowledge. Further, the education in biology should also be related to the major activities and problems of the time. A biology course consistent with our times would be more realistic, exciting and useful. Some of the applied problems like the pollution of water supplies and the biological effects of nuclear radiations are likely to interest students. The revision of a biology syllabus at the school stage should not, however, reduce the general nature of the liberal education. A revised syllabus should cover all aspects of the life sciences, the most modern as well as the most traditional. This would evidently require abandoning of both historical order in the presentation of knowledge and compartmentalization along the lines of classical disciplines. In order to include topics of modern biological interest reduction of topics of classical biology is necessary. The over-emphasis on various plant and animal phyla, for example, can certainly be reduced. Less time may be devoted to the teaching of the classical theories of evolution as these have been well developed in the textbooks and in the writings of prominent evolutionists. The introductory course in biology should give the student an understanding of biology as an investigatory science while simultaneously covering enough so as to make the student aware of the vast scope of biology. The plant and animal

groups should be taught with a view to bring out their diversity. The details of each group, if necessary, can be studied later by the student himself but the teacher need not spend any time on this in the classroom. The teaching of biology, in general, should be achievement-oriented and not syllabus-oriented. About six months to one year in the first year of the secondary school level should be spent in laying the foundation with the single aim of awakening the student's interest in the life sciences. A biology course at the secondary school level, for example, may include the study of cell, organism, organism and environment, species and population and biosphere. The study of the cell may mean the structural organisation, the genetic material, and the metabolic machinery. The level of the organism may correspond to classical disciplines like animal and plant physiology. The study of the organism in relation to the environment should be fascinating, especially for the young school children. The species and population studies may include classical and molecular genetics finally ending in the concept of species and population and their importance in evolution. At the level of the biosphere one could include topics like food chains, origin of life, and mechanism of evolution. A broad-based course such as the one outlined above should create real interest for the pursuit of biological knowledge. The diversity of plant and animal kingdom and some applied aspects of biology may be taught in the same general course or a short separate course can be given covering these and some other important topics.

Investigatory Problems and the Role of Laboratory

The laboratory work in an experimental science like biology is extremely important,

The traditional laboratory exercises of the verification type should be discouraged. The student should be introduced to the inquiry processes of science by means of investigative exercises. Such a student would not have the feeling of a bystander who reads and watches demonstrations or follows a routine laboratory procedure but of the one who actually participates in the experimentation to achieve understanding of some aspect of biology. Some of the simple investigative problems like "Do plants growing alongside a street lights show any difference in flowering in comparison with others?" or, "Are there any adaptive differences between the organisms found in dry areas and the ones found in moist habitat?" can be easily worked out by higher secondary students. In India the inquiry-oriented laboratory exercises are being conducted at the Summer Schools of the Science Talent Awardees.

The coordination between lecture and laboratory work is also very important. A mention of the excellent work of Nuffield Foundation in this connection would be appropriate. The Nuffield Biology Project has shown that a close integration of what is taught in the classroom with what is done in the laboratory is essential. In the B.S.C.S. publications theory and practical materials have been considered in separate volumes. The main purpose of these projects is to give the pupil some real experience at his own intellectual level of the essential nature of scientific study—recognition of a problem, designing of the experiment, recording of observations, and drawing of conclusions. A greater experimental approach in the laboratory would lead to a more lively and truly scientific outlook among pupils. However, it is very important to familiarize students with the tools and techniques of biology before inquiry-oriented laboratory

exercises are assigned to them. The main limitation in the practising of this approach is the lack of proper facilities for practical work in most of the schools in India. In fact, it is quite difficult to think of even a few interesting experiments, particularly the ones illustrating recent advances and which are capable of being carried out in the school laboratories with their limited space and apparatus. The number of hours per week allotted for biology practical for the higher secondary classes in most of the schools in India is only three. It is extremely difficult to compress during this time the many experiences that emphasize the important features of an experimental approach. Continuity of time and effort in pursuit of a problem are required until some analysable results are achieved. Some biologists have shown a preference for performing open ended laboratory investigations mainly with the object of showing to the students the incomplete nature in certain cases of biological investigation. Although the usefulness of such experiments cannot be doubted, it is difficult to perform these at the secondary school level where the student cannot possibly devote the amount and continuity of time which these require.

Some teachers over-emphasize the drawing of biological specimens and microscopic preparations during practical class periods. Many students spend even more time in the drawing than they do for the actual practical work. Students should use drawing as a personal thing to make their own recall easier. Sometimes the students are asked to study and draw from models and charts instead of actual specimens and slides in the practical classes. This often results in the lack of motivation for the proper understanding of the organism. For example, the real thrill which a student can get by actually observing pollination by insects can

be transformed into an extremely dull study if a student is asked to study and draw the same charts and models

Teaching Aids

The first-hand experience with the living objects is the essence of good and effective teaching in biology. The students cannot, however, discover everything for themselves as this would take too long. It may be that the observations required are beyond the child's ability or beyond the instrumentation normally available in a school. It has been felt by some biologists engaged in United Kingdom that the best form of second-hand experience is provided by the film loops. The abstract ideas should be given some visible form especially where younger children full of curiosity are being taught. Models can sometimes serve the purpose especially when something reasonably static and three-dimensional is involved. At other times film animation is the easiest way in which to present the idea. The standard procedure, as advocated in UK, is to produce film loops at the same time dealing with the telling points in the film or using animated sequences which may be of use in classroom teaching. These film strips and transparencies are particularly useful in the teaching of certain topics like ecological habitats which the students may not be able to experience easily. There are many advantages that the 8mm films recommended by the Nuffield Biology Project have over the conventional 16mm films. Firstly, each film makes only one or two points instead of a continuous stream. They are relatively cheap. Each of these lasts about 3 minutes and is intended for use with 800-E projectors. The fact that the operation of these projectors is simple and no blackout is required means that there need be little formality about using these films under classroom conditions. The students

can perfectly well view the loops unsupervised. The fact that they are silent means that a teacher can use these films to introduce experimental situations for discussion in the class. One of these films shows the sequence of the various steps used in the squash technique for making chromosome preparations. The teacher may otherwise have to demonstrate this technique several times. Another good aid in teaching is the use of sound films particularly the ones which show the sequence of biological events as they occur in nature. With the help of phase-contrast-microscopy and cine-photography, Bajer and Bajer produced a film showing different nuclear changes during mitosis. In this film it is thrilling for the young children to see the separation of chromatids during anaphase. More and more of such educational films in biology should be produced.

Another aspect which deserves consideration is the need for a close co-operation between the biology teachers and the commercial firms manufacturing biology apparatus. The Phywe Aktiengesellschaft, Göttingen, W. Germany, in consultation with the biology school teachers have made a cheap assembly kit with the help of which 30 specific physiology experiments can be performed. This is a very encouraging trend where the biology teacher and the industrialist have gone hand in hand for the benefit of biology teaching. This is important as the industrialist may sometimes put on the market a product which may be beyond the technical skill of the school teacher.

The personal improvisation of teaching aids by the teachers and students would give them a better insight and understanding of the subject. The cost of the improvised teaching aids being much less than the commercial product, a considerable saving in the meagre biology budget of schools would be achieved. The organisation of science

clubs, exhibitions and competitions amongst students may, to some extent, help in achieving this objective.

For the teaching of biology a well-planned school garden is an absolute necessity. In the first instance, the garden is meant as an aid in biology teaching in the lower forms. Secondly, it would provide material for demonstration and student's experiments in connection with the investigatory problems. A number of direct observations can also be made from the plants growing in a garden.

Evaluation of Students

The inquiry-oriented biology courses naturally lead to a demand for tests designed to reflect the philosophy of such courses. Quite obviously, there is little value in teaching students in an inquiry-oriented fashion and then evaluating their performance merely on the recall of facts. Many biology teachers test for specific recall of information such as the names of bones, orders of insects, and botanical names of plants. For this type of questions it is more important to memorize than to gain an understanding. All biologists would agree that students should gain a good understanding of the fundamental biological principles rather than memorize factual material. Many would probably include attainment of problem-solving activities and attitudes as an important aspect of acquiring this understanding. Regardless of the type of examination used, the purpose of testing in the biological sciences is to assess the extent to which desirable changes in the students' knowledge, intellectual abilities, attitudes and values have occurred as a consequence of his educational experiences. These educational experiences would include the lecture, laboratory discussion, problem-solving, field work, and other related activities. Suitable evaluation

techniques must be designed to measure these abilities. Most teachers are aware that students are very quick to adapt their study habits to the form and style of evaluation to which they will be exposed. The objective and thought-provoking type of questions are certainly much better than the straight essay type of questions requiring memorized knowledge which is forgotten much sooner than learnt. The teachers should keep day-to-day record of the students attitude towards learning.

Training of In-Service Teachers

The fact that many teachers of secondary schools are poorly trained in their discipline may possibly account for the lack of impact of secondary school biology teaching. Therefore, no matter how good the available materials, the teachers' background limits his effectiveness. The new method of teaching demands much of originality both from the teacher and the student. To appreciate the requirements of inquiry method, the teacher must himself have gone through training by inquiry and investigatory methods. The only way to help established teachers is by arranging in-service refresher courses for them. These courses should be based on laboratory and field work rather than on lectures alone. The Summer Institutes for Secondary School Teachers in India are organized with a view to introducing the school teachers to new scientific developments and to acquainting them with modern curricula and new techniques of teaching and demonstrations. These provide stimulus to school teachers to improve their professional competence. This is sought to be achieved by bringing together groups of science teachers from schools and universities for about six weeks during the summer vacation, and by making available to them modern textbooks, improved laboratory techniques, and

teaching aids. The institutes lay emphasis on practical laboratory work, demonstrations and lectures on modern topics by specialists. The programme provides an opportunity to school teachers to discuss their problems with fellow teachers and university teachers. The objectives of the program are achieved by the utilisation of the facilities and services available in Indian universities. The training enables teachers to conduct experiments with simple and improvised apparatus and to strengthen the capacity of the teachers for motivating able students to develop an aptitude for research. It is expected that by 1971 nearly 50 per cent of the total number of biology secondary school teachers in India would be trained through these Summer Institutes. This project is being conducted by the National Council of Educational Research and Training (NCERT) and the University Grants Commission (UGC), India in collaboration with United States Agency for International Development (US AID) and the United States National Science Foundation (US NSF). The recently established National Council of Science Education (NCSE), India, has taken over the responsibility for the improvement of science education. The NCSE works in close co-operation with the NCERT, UGC, US AID and US NSF.

Summary and Conclusions

The importance of basic researches in the teaching of biology at the school level has been discussed. This should reflect the present state of knowledge and can be achieved by a constant revision of curricula. There

is an urgent need for identifying the organisms which are most suitable for teaching biology in any particular geographical region. The various communication channels for transmission of recent findings and their impact to the teachers and pupils have been pointed out.

The method of imparting instruction is as important as giving the latest available information. The desirability of teaching biology by inquiry and investigative methods has been emphasized. These objectives can be achieved by adopting a broad-based syllabus which may include both the modern and traditional topics. The course in biology should be conducted by actual experimentation so that the pupils are able to realise the significance of the study of life sciences. For this a well-equipped laboratory is a pre-requisite. The importance of teaching aids like the use of 8 mm silent films and sound films has been pointed out. The advantages of the manufacture of apparatus by the commercial firms in consultation with the biology teachers have been discussed. The new method of teaching also demands a change in the method of evaluation of students. The use of objective and thought-involving type of questions has been advocated. Although the usefulness of the investigative methods of teaching biology has been realized by many, it is not being practised as widely as desired. One possible reason for this may be the limitation due to the poor background of the teachers. This can be easily overcome by in-service training of school teachers. The Summer Institute programme in India is intended for this purpose.

In conclusion, we wish to emphasize that merely the improvement of curricula and teaching aids will not lead to the proposed goal. Further, the basic researches should form the foundation for the formulation of the

The National Council of Educational Research and Training through its Department of Science Education has started projects with the aim of improvement of science Education at school level. One of these is the Project for the Teaching of Science and Mathematics which is in the third year now.

curriculum, and the role of basic researches urgently is a reorientation of teaching methods which should indeed be achievement-oriented. What is needed most

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Classroom experiments

Fun with Chemistry

Some simple experiments for extra curricular activity in chemistry

By

Y.I. NAUMOV

and

N.K. SANYAL

THE main objectives of teaching chemistry as a separate discipline are not only to give the pupils a systematic knowledge of the subject but also develop their practical skills and prepare them for an understanding of the many phenomena involved in industry and agriculture. Through chemistry it is possible to develop keenness of observation, analysis of observation and development of logical thinking. One of the important pedagogical tasks of teaching chemistry is to create a motivation and interest in the study of the subject. This is not always possible through the simple classroom experiences. There are various forms of extra curricular activities like organisation of chemical

clubs, chemistry quizzes, chemical olympiads etc. We would like to discuss in this article some simple experiments in chemistry that are easy to organise, inexpensive and at the same time interesting enough for the pupils. Almost all schools have the necessary chemicals and equipments needed for these experiments which may be organised in the form of a chemical show.

To keep an element of interest in each chemical show, discussed later, it is important to keep the following things in mind :—

- (a) The experiment in the chemical show should be the answer to a felt problem which should be investigated by the pupil.
- (b) If any pupil from the audience is keen to find the solution by experiment he should be encouraged to do it.
- (c) All necessary preparations of solutions as well as oral questions should be made before hand.
- (d) It would be highly desirable to relate the experiments in the show with the topics covered in the classroom lessons.
- (e) The experiment should be performed in a dramatic way including use of suitable words, magic sticks, lighting effect etc. to bring the element of surprise and magic.

Experiment 1

Conversion of water into a coloured "juice" and again into water

Pose a question whether it is possible to convert water into a coloured liquid and then again change it back to colourless water.

Take three 250 ml beaker (A, B. & C). Fill about a third part of each beaker with

a colourless liquid and let them stand on the demonstration table. Pour a part of the contents of beaker A into beaker B, and stir with a glass rod and demonstrate the conversion of water into a red solution. For effective demonstration it may be better to use a white screen behind the beaker.

Then add a part of the solution from beaker C into beaker B and see that it again becomes colourless. The experiment can be repeated once again using the same sequence of operations

Explanation

Beaker A contains 20% solution of caustic soda, Beaker B water with 5 to 10 drops of alcoholic solution of phenolphthalein, beaker C 20% solution of sulphuric acid. This experiment demonstrates the action of indicators on acids and alkalis.

Experiment 2

Conversion of water into different coloured liquids

Place on the table one litre beaker with water and four 200 ml capacity beakers. Call four pupils to examine the empty beakers and get the beakers washed by them by tap water. Then pour water into the small beakers one by one from the big beaker and demonstrate that the liquid in each beaker has different colour.

Explanation

The big beaker is filled with tap water. After this four smears of soap along with a few particles of four different aniline dyes are placed on the upper inner surface of the rim of the beakers at right angles to each other. While pouring water the experimenter has to turn round the large beaker in such a way that water comes into contact with one dye only (it requires a good practice

before hand to pour water in such a way that the dyes do not get mixed).

Experiment 3

Smoke without flame

Ask the pupils the question, what is a flame and is it possible to make smoke without any flame. Then put two small china dishes together to show the formation of heavy smoke in a moment.

Explanation

The china dishes contain respectively concentrated solutions of hydrochloric acid and ammonia. On mixing together heavy fumes of ammonium chloride are formed.

Experiment 4

Burning lump of sugar

Ask the pupils as to who can burn a lump of sugar. Let pupils try to burn a lump of sugar held in a pair of tongs by a burning match stick, spirit lamp flame or even a gas burner. Pupils may fail to do it and the lump of sugar merely melts and turns brown but does not burn. Then the experimenter puts a very small amount of cigarette ash on the lump of sugar and shows that the lump burns with a yellow flame easily even by the flame of a match stick.

Explanation

This is due to the phenomena of catalysis. The ash of tobacco accelerates the oxidation of sugar to such an extent that it can easily catch fire by a match.

Experiment 5

Colouring water blue by using a white powder

Pose the problem whether is it possible to make water to a blue colour by adding any

white substances. Provide a few samples of white substances in powder form in wide glasses on the table and let pupils try. After unsuccessful attempts of pupils the teacher shows his magic by putting in a beaker of water one of the white powders lying on the table and using the magic stick as a stirrer.

Explanation

Keep on the table before hand the following white salts in small watch glasses NaCl , Na_2SO_4 , NaNO_3 , K_2SO_4 , BaCl_2 , KCl , KNO_3 , CuSO_4 (Anhydrous). The only white powder which will be able to form the blue solution is anhydrous CuSO_4 forming hydrated crystals of copper sulphate. This is used as a sensitive test for detecting the presence of water.

Experiment 6

Lighting a Spirit Lamp by a magic stick

This is an experiment to show the lighting of a wick of spirit lamp by touching it with a glass rod. The glass rod is first placed in a porcelain mortar containing a black substance and then touched to the wick of the spirit lamp. The wick is lighted in a moment. The teacher may invite two or three pupils and ask them to repeat the experiment.

Explanation

The china dishes contain a mixture of potassium permanganate with concentrated sulphuric acid. On stirring with a glass rod immediately the unstable anhydride Mn_2O_7 is formed. This extremely powerful oxidising agent oxidises the alcohol readily to make it burn as a flame. This experiment can be related to the topic "Reactions of oxidation and reduction".

Experiment 7

Burning cloth to give different coloured flames

Take two small pieces each of white, red, green and yellow cloth on the table. The pieces should be of same size and shape. Put the question "What will be the colour of the flame when the different coloured pieces of cloth are burnt?" Demonstrate by burning one piece of each colour on the flame that a yellow flame is always obtained. Then touch the other pieces of cloth with the magic stick and show by burning that the red, green and yellow pieces burn with a colour of the flame corresponding to the colour of the cloth.

Explanation

Each kind of cloth has two strips (A & B). The strips A of each are wetted in water and dried. The strips B should be dipped in the following saturated solutions and dried:—

- (i) Yellow strip in sodium nitrate.
- (ii) Red strip in strontium nitrate.
- (iii) Green strip in barium nitrate.

Dry the strips after soaking and repeat the soaking two or three times in the last two cases. While demonstrating the pieces A are to be burnt first, to show that the same type of flame is obtained in each case. Then burn the pieces B separately where the colour of the flame will be according to the colour of the cloth. This is due to the nature of the salts present which affect the colour of the flame. This experiment can be linked with the study of "Identification of mineral fertilizers—flame test".

Experiment 8

Invisible writing

Show the class a large sheet of white paper which looks quite clean. Fix the sheet on

the blackboard and spray on it by a sprinkler a fine spray of a colourless liquid filled in the vessel. Show that a red writing appears instantly.

Explanation

The writing on the paper was done by using alcoholic solution of phenolphthalein and drawing afterwards. The bottle of the sprinkler is filled with weak solution of a base (like caustic soda) ammonia or lime water. Thus again the action of indicators on bases is shown.

Experiment 9

Chemical Volcano

Place an asbestos gauge on the table. Place on it a heap of a yellow powder and tell the pupils that we are going to make the model of an active volcano. To make the model erupt, start the burning with the help of a lighted splinter. A better effect can be obtained if the lights in the rooms are switched off to enable pupils to see the eruption.

Explanation

The imitation of the volcanic eruption is based on the following reaction. $(\text{NH}_4)_2\text{Cr}_2\text{O}_7 \longrightarrow \text{Cr}_2\text{O}_3 + \text{N}_2 + 4\text{H}_2\text{O}$.

The reaction has to be initiated by heating a little with a burning splinter. Then it goes on automatically.

Experiment 10

Black writing on paper

Fix a white sheet of paper on the blackboard and touch it with a smouldering splinter. Step by step we can see the outlines of figures geometrically or animals etc. developing on the paper in the form of black line drawings.

Explanation

Any one of the following salts, NH_4NO_3 , NaNO_3 to KNO_3 may be used to make the invisible ink. With the help of this solution line drawings are made on the white sheet of paper by a broad nib or a fine brush. For successful demonstration, the following conditions must be observed:

- (a) The line of the drawing should not cross anywhere.
- (b) The line should be thick enough to contain enough salt after drawing. It is better to apply the invisible ink twice or thrice after drawing.¹

The Medicine Dropper and a Simple Balance

HY RUCHILIS

Adjunct Professor of Education and Director, Educational Media Centre, Fairleigh Dickinson University, Madison, New Jersey, 07940, U.S.A.

SIMPLE household devices such as the medicine dropper often provide opportunities for individual student investigations involving observation, making and testing hypotheses, and logical thinking. The investigations suggested in this article could begin during a discussion of air pressure, and extend to the medicine dropper as an illustration of the action of air pressure. Material needed for the investigation include enough medicine droppers and transparent container of water for small groups of children. A cooking baster or fountain-pen

1. Portions of this article are reproduced with permission from *Science and Children*, volume 5, number 8, May, 1968, copyright 1968 by the National Science Teachers Association, 1201 Sixteenth Street, N.W., Washington.

ler can serve for teacher demonstration. Have the children observe what happens when the medicine dropper is submerged in water, squeezed, and then released in the water (Fig. 1). The formation of bubbles

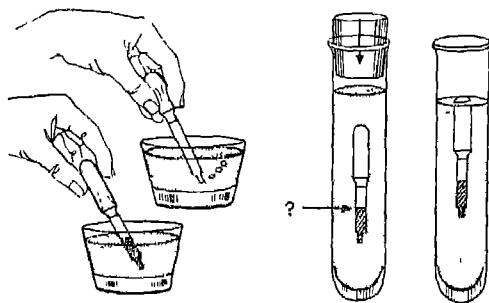


Fig. 1 Medicine Dropper

when the rubber is squeezed, the entrance of the water into the dropper when the rubber is released, and the release of drops when the rubber is again squeezed all serve to illustrate the action of air pressure.

These observations and discussions can serve as the starting point for a number of interesting investigations which the children can carry out on their own, as follows:

1. How many drops are there in a cup of water

Individual drops are counted as they are emptied into a small container (such as a vial) until they fill the vial. Then the number of full vials of water required to fill a cup is measured. An estimate of the number of drops of water in the cup may then be obtained by multiplication.

Advanced children could use this method in connection with a cylindrical graduate to measure the volume of a drop of water.

2. Is a drop of water larger, smaller, or the same size as a drop of salad oil (or other liquid) ?

A mark is made on the side of the dropper

with a wax pencil, or by a pencil on clear tape attached to the side of the dropper. The dropper is filled to the mark with water and then with other liquids. The number of drops required to empty the dropper for each liquid provides a comparison of drop sizes.

3. How much does a drop of water weigh?

Drops are emptied into a container on a balance until a specified weight—such as an ounce—is reached. The weight of a drop of water may then be obtained by division.

A 2-paise coin* weighs very close to 1 gram and can be used as a standard weight in the metric system.

4. How does the weight of a drop of water compare with the weight of a drop of salad oil?

The procedures of the previous investigations may be used to weigh a drop of salad oil and compare its weight with that of a drop of water.

5. Cartesian diver

Suggest to the children that they make a "diver" that can go up or down in water at will.

A dropper is filled with water by squeezing it in water and releasing it until it just barely floats when placed in water in a glass. The dropper is then transferred to a tall narrow vial almost filled with water and the vial covered with a cork or rubber stopper. Downward pressure on the cork causes water to enter the dropper, whereupon it sinks. Releasing the pressure on the cork restores the original situation and causes the dropper to rise to the top (Fig. 1).

The observations and explanations for the action of the diver provide an excellent opportunity for scientific reasoning.

* This refers to the aluminium-magnesium coins minted after September 1965,

Home-made equal-arm balance.

An equal-arm balance sufficiently sensitive to respond to the weight of a few drops of water can be made from a long, thin stick (tree branch) or wire, about 45 cm in length (Fig. 2).

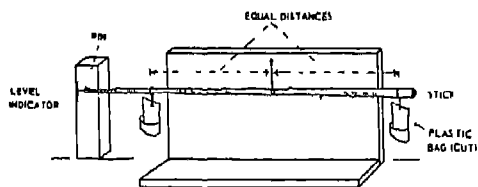


Fig. 2. A Simple Balance

Find the approximate center of gravity of the stick or wire by balancing it horizontally across a finger. Tie a thread to the stick at that point and suspend it by tying the string to an overhead support. Attach a pin or thin nail to the narrow end of the stick (or wire) to serve as a reference mark. Slight imbalances may be corrected by shaving off the stick on the heavy side, or by tying a small object (clip, nail) to the appropriate position on the stick or wire.

The support may be as simple as a hook in the under side of a shelf. A more elaborate stand can be made as shown in the illustration. It has the important advantage that the stick is restricted in its swinging, thereby making the balance easier to handle.

A "level indicator mark" on a vertical object positioned near one end of the stick makes it possible to accurately restore the balance to the original position when a weight has been added to one side. Ruler marking on such a vertical object can be calibrated in terms of tenths; or even hundredths of a gram, thereby increasing the utility of the balance.

Objects and weights may be suspended from the balance by means of small plastic bags tied to the stick, as shown. These must be positioned so that the distances from the pivot are equal. Accessibility to the contents of each bag is improved by cutting part of one side so as to form a pouch.

Standard weights are generally not readily available. However, coins can serve as substitutes because of the high degree of uniformity in weight. Even moderately worn coins rarely differ in weight from new coins by more than a few tenths of a gram. It is a nice project to determine the weights of these different kinds of coins.

Smaller weight standards, down to one-tenth of a gram or less, may be made by balancing a number of very small, uniform objects against the known weight of a coin and then obtaining the weight of one small object by mean of calculation. The number of such small objects required to equal approximately 1/2 gram, 1 gram, etc., may then be determined.

Small buttons, tiny nails, or even small squares of paper, thin cardborad, or metal foil, can serve as uniform small weights. These can be bundled to form sets of standard weights. Larger standard weights of 10, 20, and 50 gram can be made by filling small vials or plastic bags with suitable quantities of sand.

Such home-made scales will prove useful for a wide variety of weighting projects—weighing insects, seeds, drops of water and of other liquids, paper clips, buttons, grains of sand, etc. Children who build such simple balances will obtain valuable experience with scientific measurement encountering many of the types of problems faced when one uses more sophisticated equipment. The experience is all the more valuable because the child will be starting from scratch, with no help at all from factory-built gadgets.

Improved methods for showing Convection Currents

C. RAMAKRISHNAYYA

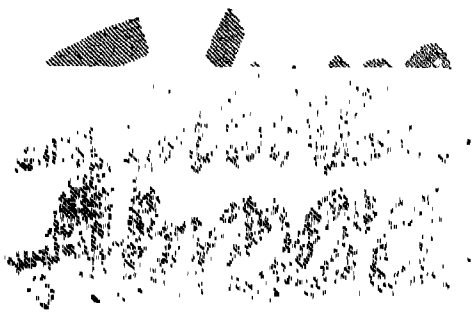
THE traditional demonstration of convection current by dropping a crystal of potassium permanganate in a beaker before heating it, suffers from the defect that either water gets a streak of coloured water before heating or water gets coloured while heating. This makes it difficult for children to form the idea of a current. The following experiment suggests some modification so that this difficulty is not met with.

Experiment

A small crystal of potassium permanganate was enclosed in a small gelatine capsule purchased from a medical stores for 5 paise.

To keep it under water, it was tied to a lead piece or two or three lead shots may be enclosed in this capsule. The capsule was put at the bottom of a beaker half full of water. The flame of a spirit lamp was directly brought under the capsule in the beaker on a tripod stand without using a wire gauze. Air bubbled out. A pink coloured streak-like column of water ascended conspicuously from the bottom of the beaker and came down completing the convection current.

In this experiment a little time is to be allowed till the material of the capsule gets melted. The encapsulation of the crystal has become necessary to show the coloured convection currents from the bottom of the beaker in colourless water introduction of the sinker may be an irrelevant aspect of the experiment. But as the pupil is already acquainted with the use of a sinker in density experiments, it is hoped, he would understand the reason of using it.



Newlight on Vision

JOHN NEWELL

Research on human vision covers an enormous number of subjects and disciplines. A great deal still remains to be discovered about the optical properties of the eye. Then there are the ways in which the incoming light impulses make retina fire off nervous impulses to the brain. There is the need for swift diagnosis of diseases such as trachoma—one of the commonest illnesses in the world. There are continual developments in eye surgery. There are purely practical things to be done, for example, helping divers to see better under water. All these and many other problems involved in vision are being studied at the London Institute of Ophthalmology

ONE of the greatest problems in studying the optics of the human eye is the small scale of the machinery involved, because the eye is built to cope with the very short wavelengths of visible light. How much easier it would be if we were dealing with an eye built to receive radio waves, which are thousands of times longer in wavelength. But of course the eye would have to be built on the scale of a radio telescope.

From SPECTRUM, 50, 1968

For use in a new research project recently begun at the Institute, Dr. R.A. Weale has built a model of a small part of the human eye ten thousand times bigger than the real thing. The model is concerned only with the layers of light-absorbing pigment in the sensitive cells of the retina, the so-called rods and cones. These contain flat sheets of pigment, arranged on top of each other with spaces in between, like shelves in a commodious cupboard. Obviously this structure must have a function and Dr. Weale is trying to find out what it is, with the aid of his model rods and cones. He is at present only interested in the effect of the superimposed sheets of pigment and he has modelled these by setting up a row of sheets of cardboard. Light cannot penetrate the cardboard, and he cannot in any case use light because, if you scale up the eye, then you must also scale up the light and this means multiplying the wavelength of light by the same factor, ten thousand. This gives radar waves, microwave. So Dr. Weale's model of the rods and cones is a microwave transmitter beamed at the row of sheets of cardboard, with a receiver on the other side. An oscilloscope shows what is received and how microwaves are affected by the cardboard sheets.

Dr. Weale has a hypothesis to explain why the rods and cones are built with sandwich-like sheets of pigment. He has found that when the microwave source faces the sheets directly then a very powerful signal gets through to the receiver beyond, but if the waves arrive at even a slight angle then the amount of the signal that gets through falls off to nothing very sharply. Therefore, it may very well be that the layers of pigment sheets in each single cell are used to filter out light coming from an angle, so that only light striking a cell more or less at right angles gets through to set off a nervous signal. As

the retina is curved, this could enable each part of it to see light coming only from one particular angle. A coherent picture could be provided, with different elements contributed from different parts of the eye.

British Royal Naval divers have descended into deep seas and also spent time in pressure chambers simulating deep sea conditions to show that it is possible for men to work under water down to depths around 300 metres, without needing elaborate diving suits. This means that divers should be able to work quite freely on nearly all the world's continental shelves. As the search for oil, gas and minerals spreads and as farming the seas becomes a realistic proposition, men are going to have to spend more and more time under water.

One of the main problems here is the limitation of human vision caused by the light-scattering and light-absorbing properties of ordinary water.

Dr. John Lithgow, also working at the Institute, has been investigating ways to improve human vision under water. For some time it has been known that fish have eyelids which act as polaroid filters and last year Dr. Lithgow discovered why. Water has a polarising action on sunlight and if the eye is adapted to perceive the plane of polarisation of light then this can improve vision. We can improve our own undersea vision by wearing polaroid goggles with filters able to adjust to the different directions from which we perceive light under water.

There are other methods too. The ordinary diver wastes time dark-adapting his eyes before he goes under water, where there is much less light. If, instead, the diver were to don a red tinted visor for an hour or two before going down then he would have dark-adapted vision from the start. Thirdly, vision can be improved by wearing certain

coloured filters, because the main problem in seeing in the sea is not so much insufficient light but an excess of irrelevant light, which needs to be cut out to give the clearest possible picture. In different water conditions the irrelevant light is propagated at different wavelengths which means a selection of filters is necessary.



The kind of conditions divers have to work in when under water.

Dr. Lithgow has devised an instrument to study the best filters for different conditions. He has used this to carry out experiments both in the English lakes and in the Mediterranean. Another and longer term approach is to study the different light-absorbing pigments found in different species of fish. These pigments are able to receive various wavelengths and by having more of one type and less of another fish are able to pick out some wavelengths and filter other. The Medical Research Council's unit working on vision at the Institute of ophthalmology is studying these fish pigments in detail. They may ultimately prove the best means of improving human vision under water. Even using techniques known how, Dr Lithgow is certain that it would be possible to extend the range of underwater vision by at least 25 per cent.

Speedier Trachoma Diagnosis

One problem in the treatment of trachoma is the length of time involved in diagnosing

uncertain cases of the disease. Since 400 million people in the world today are in areas where trachoma is prevalent and are potential sufferers, any new development in research on this disease is welcome. A technique for growing trachoma virus in tissue culture has been developed by two doctors working at the Institute which will speed up diagnosis of the disease.



An eye blinded as a result of trachoma

The conventional method involves inoculating scrapings taken from the eyes of a suspected trachoma case into fertile hens eggs. After two to four weeks it is possible to tell whether or not the inoculation contained the virus.

In the new method, human cells in tissue culture are first treated with X-rays to reduce their innate capacity to fight off infection, and render them as susceptible as possible to a trachoma virus. Then scrapings from the suspected case are added to the culture and forced right up against the cells by centrifuging. Thirty hours after three different and very clear chemical tests will reveal any trachoma virus present.

Although this technique is so much faster than the egg inoculation method, it is not so easy to apply and so is bound to be hard to introduce into tropical areas where swift diagnosis of trachoma is most needed. Nevertheless the research team working on the

technique are hoping to simplify the method and make it valuable everywhere.

Eye Surgery by Laser

A new application in eye surgery for the intense beam of light from a laser is also being developed. Previously the laser beam has been used to weld displaced retinas into the back of the eye. The new technique uses the laser to punch a hole about a millimetre across through the iris, the membrane which like the iris of a camera allows variable amounts of light through the hole in the centre, the pupil. The eye is continually washed by fluid which runs down between the iris and the lens and through the pupil into the anterior chamber in the front of the eye. Sometimes this channel gets blocked and a surgical operation is required to cut a little hole in the iris to clear it. Experiments on animals have shown that this surgery could be replaced by two or three very brief flashes from a laser which would painlessly burn a hole through the iris. It should be possible to use this treatment on an out-patient basis because it is so simple.

Switching on the Eye

Today, research on the mechanism of vision has reached the point where scientists are studying the response of individual cells or small groups of cells over short periods of time. The first stage in vision is the process by which light is absorbed by pigment in the rods and cones. This stimulates them to send electrical messages along the nervous pathways to the brain. The first stage in investigating how the eye is switched on—what makes the rods and cones fire off their message—is to shoot a controlled flash of light into them and measure their response. The difficulty is that for technical reasons, it is possible to use only very short flashes of light

in this kind of experiment. Dr. R. Fatehchand has managed to push the length of flash used from the previous record, one ten thousandth of a second, to one twenty-fifth of a second. This has made it possible to show how the rods and cones react to their flash of light. They behave in the simplest way possible, just like a photoelectric cell, simply firing off electricity for as long as the flash lasts and then stopping.

Until this research was done, scientists had to reckon with the possibility that the rods and cones reacted in any of a number of ways. Each of these ways would have meant building up a different theory of the detailed workings of the eye.

A Lesson in Inequalities for the Twelfth Year Mathematics Student—Cauchy's Inequality

CHARLES L. RIGGS
PAUL E. THOMPSON

Texas Technological College,
Lubbock, Texas, U.S.A.

STUDENTS are introduced to inequality symbols and to the meaning of "greater than" and "less than" early in their education. In fact, one experimental programme of mathematics in the U.S.A. introduced inequalities in the first grade and continued solving problems involving inequalities in the second and third grades (1). The College Entrance Examination Board in the U.S.A. suggested

in 1959 that linear equations and inequalities in one variable be presented in elementary mathematics, grade nine, essentially a course in algebra (2). The student who pursues a study of mathematics from kindergarten through grade 12 usually has many introductions to the inequality. He has had experience in finding the solution sets of the inequality. However, the college teacher of calculus has found the college freshman with the 12th and 13th year mathematics programme background lacking in understanding of inequalities. At this level, the absolute value inequality should be completely understood.

This paper is an attempt to present an interesting discussion and proof of the Cauchy inequality for the twelfth year mathematics student. The proof is presented on the assumption that the student is in a course similar to the elementary functions course as suggested by CEEB (3). The student should have a knowledge of functions, inverse functions, the graphing of these functions on the rectangular coordinate plane, and the integral

$\int_a^b f(x) dx$ as related to area. Of course,

if the school mathematics student does not have this background, then this discussion could be delayed and presented as a topic of interest for the college freshman.

The proof is not obvious and might seem beyond the grasp of the twelfth year student. However, considering a typical student approach, i.e., starting at the end and returning to the beginning, a proof is developed that is understandable and enlightening. The Cauchy inequality was published in 1821 (5). Mathematicians usually show that the Cauchy inequality is a special case of Holder's inequality, published in 1889 (6). Young's inequality appeared in print in 1912 (7). Starting with Young's inequality which can

be easily demonstrated geometrically, Holder's inequality can be presented, then Cauchy's inequality follows as a special case of Holder's inequality (8). The graphing of the function and its inverse and the algebra involved in the presentation is of the level of work done by the twelfth year mathematics student in the United States.

The Problem

Consider the proof of a typical algebraic inequality $2ab \leq a^2 + b^2$, and a and b real numbers. The usual algebraic solution is to consider $(a-b)^2 \geq 0$, then $a^2 - 2ab + b^2 \geq 0$ and $a^2 + b^2 \geq 2ab$. Once performed, this proof seems trivial.

Consider the proof of the Cauchy's Inequality $(ac+bd)^2 \leq (a^2+b^2)(c^2+d^2)$. Expansion and application of cancellation laws yields $2acbd \leq b^2c^2 + a^2d^2$. Letting $bc=\gamma$ and $ad=\beta$, then $2\gamma\beta \leq \gamma^2 + \beta^2$, which is the trivial algebraic inequality we previously developed.

Let us now consider the more sophisticated version of the Cauchy inequality

$$\left(\sum_{i=1}^n a_i b_i\right)^2 \leq \left(\sum_{i=1}^n a_i^2\right) \left(\sum_{i=1}^n b_i^2\right).$$

Cauchy's inequality is a special form of Holder's inequality; that is, Holder's inequality

$$\sum_{i=1}^n a_i b_i \leq \left(\sum_{i=1}^n a_i^h\right)^{\frac{1}{h}} \left(\sum_{i=1}^n b_i^k\right)^{\frac{1}{k}},$$

where $a>0$, $b>0$, $h>1$ and h and k are related by the equation

$$\left(\frac{1}{h}\right) + \left(\frac{1}{k}\right) = 1 \text{ or } k = \frac{h}{h-1}.$$

Letting $h=k=2$, Holder's inequality becomes

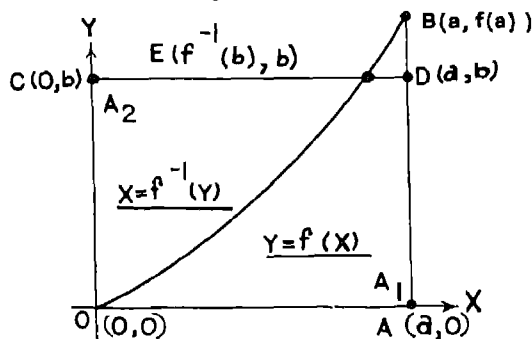
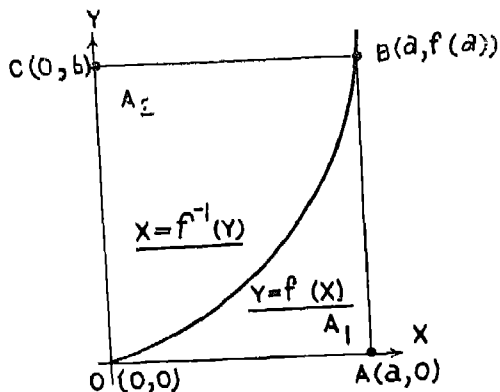
$$\sum_{i=1}^n a_i b_i \leq \left(\sum_{i=1}^n a_i^2\right)^{\frac{1}{2}} \left(\sum_{i=1}^n b_i^2\right)^{\frac{1}{2}}$$

Squaring both sides then

$$\left(\sum_{i=1}^n a_i b_i\right)^2 \leq \left(\sum_{i=1}^n a_i^2\right) \left(\sum_{i=1}^n b_i^2\right)$$

which is Cauchy's inequality. Thus Cauchy's inequality is proved if we can prove Holder's inequality. Also we must meet the conditions $a>0$, $b>0$, $h>1$, and $k = \frac{h}{h-1}$.

Let us consider Young's inequality. If $y=f(x)$ is a continuous increasing function for all $x \geq 0$, $f(0)=0$ and $f(a)=b$, a and b real numbers greater than 0, then the inverse function $x=f^{-1}(y)$ exists and is also continuous and everywhere increasing for all $y \geq 0$. $f^{-1}(0)=0$ and $f^{-1}(b)=a$ and the graph of f and f^{-1} are the same. (Fig. 1).



Area $A_1 = \int_0^a f(x) dx$, $0 \leq x \leq a$. $A_2 = \int_0^b f^{-1}(x) dx$, $0 \leq x \leq b$. The area of rectangle OABC = ab and therefore $ab = A_1 + A_2$ or $ab = \int_0^a f(x) dx + \int_0^b f^{-1}(x) dx$ for $f(a) = b$.

Now $f(a) = b$ or $f(a) > b$ or $f(a) < b$. If $f(a) > b$, then the area of the rectangle OADC = ab is less than the area of $A_1 + A_2$ (Fig. 2). If $f(a) < b$, the area of the rectangle OAEC = ab is also less than the area of A_1

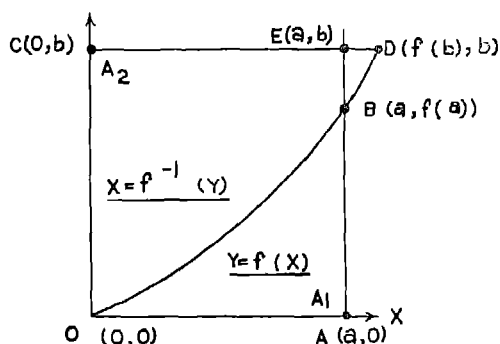


Fig. 3 $f(a) < b$

+ A_2 . (Fig. 3). Combining the results of Figures 1, 2, and 3 we have Young's inequality, given a function f continuous and everywhere increasing on the interval $[0, a]$, $f(0) = 0$, its inverse function f^{-1} exists and is continuous and everywhere increasing on the interval $[0, b]$, $f^{-1}(0) = 0$. Then for $a \geq 0$ and $b \geq 0$,

$$ab \leq \int_0^a f(x) dx + \int_0^b f^{-1}(x) dx,$$

where equality holds if and only if $f(a) = b$. Observe that if $f^{-1}(x) = x$ then $f^{-1}(x) = x$ and Young's inequality is a quite familiar one, i.e.,

$$ab \leq \int_0^a x dx + \int_0^b x dx = \frac{a^2}{2} + \frac{b^2}{2},$$

$$2ab \leq a^2 + b^2 \quad !!$$

Now since we are interested in deriving Holder's inequality we shall use Young's inequality and let $f(x) = x^n$, $n > 0$ then

$$f^{-1}(x) = x^{\frac{1}{n}} \text{ and}$$

$$ab \leq \int_0^a x^n dx + \int_0^b x^{\frac{1}{n}} dx = \frac{a^{n+1}}{n+1} + \frac{b^{\frac{1}{n}+1}}{\frac{1}{n}+1}$$

Let $h = n+1$ and $k = \frac{1}{n}+1$ and substituting,

$$\text{we have } ab \leq \frac{a^h}{h} + \frac{b^k}{k}$$

The relationship between h and k is shown by the sum $\frac{1}{h-1} + \frac{1}{\frac{1}{h-1}+1} = 1$ an inter-

esting algebraic sum satisfying this condition of Holder's inequality. The equation $\frac{1}{h} + \frac{1}{k} = 1$ is necessary for our proof of Holder's inequality. We derived the inequality

$$ab \leq \frac{a^h}{h} + \frac{b^k}{k} \text{ from Young's in-}$$

equality under the conditions $a > 0$, $b > 0$

$$\text{and } f(x) = x^n, n > 0, \text{ Therefore } ab \leq \frac{a^h}{h} + \frac{b^k}{k}$$

$$a > 0, b > 0, h > 0, k > 0, \text{ and } \frac{1}{h} + \frac{1}{k} = 1$$

Continuing the proof of Holder's inequality consider the finite sums

$$A = (a_1^h + a_2^h + \dots + a_n^h)^{\frac{1}{h}} \cdot \left(\sum_{i=1}^n a_i^{\frac{1}{h}} \right)$$

and

$$B = (b_1^k + b_2^k + \dots + b_n^k)^{\frac{1}{k}} \cdot \left(\sum_{i=1}^n b_i^{\frac{1}{k}} \right)$$

and refer to the inequality $ab \leq \frac{a^h}{h} + \frac{b^k}{k}$.

Letting $a = \frac{a_i}{A}$ and $b = \frac{b_i}{B}$, for $i = 1, 2, \dots, n$

we have

$$\left(\frac{a_i}{A} \right) \left(\frac{b_i}{B} \right) \leq \frac{1}{h} \left(\frac{a_i}{A} \right)^h + \frac{1}{k} \left(\frac{b_i}{B} \right)^k$$

which gives upon summing

$$\frac{a_1 b_1 + a_2 b_2 + \dots + a_n b_n}{AB} \leq \frac{1}{h} \frac{(a_1^h + a_2^h + \dots + a_n^h)}{A^h} + \frac{1}{k} \frac{(b_1^k + b_2^k + \dots + b_n^k)}{B^k}$$

$$\text{Now if } A = (a_1^h + a_2^h + \dots + a_n^h)^{\frac{1}{h}}$$

$$\text{and } B = (b_1^k + b_2^k + \dots + b_n^k)^{\frac{1}{k}}$$

then substitute and simplify to obtain

$$\frac{a_1 b_1 + a_2 b_2 + \dots + a_n b_n}{(a_1^h + a_2^h + \dots + a_n^h)^{\frac{1}{h}} (b_1^k + b_2^k + \dots + b_n^k)^{\frac{1}{k}}} \leq$$

$$\frac{1}{h} \frac{a_1^h + a_2^h + \dots + a_n^h}{[(a_1^h + a_2^h + \dots + a_n^h)^{\frac{1}{h}}]^h} + \frac{1}{k} \frac{b_1^k + b_2^k + \dots + b_n^k}{[(b_1^k + b_2^k + \dots + b_n^k)^{\frac{1}{k}}]^k} \\ \frac{1}{h} (1) + \frac{1}{k} (1) = 1.$$

Multiplying both sides of this inequality by

$$(a_1^h + a_2^h + \dots + a_n^h)^{\frac{1}{h}} (b_1^k + b_2^k + \dots + b_n^k)^{\frac{1}{k}}$$

we have

$$a_1 b_1 + a_2 b_2 + \dots + a_n b_n \leq (a_1^h + a_2^h + \dots + a_n^h)^{\frac{1}{h}} (b_1^k + b_2^k + \dots + b_n^k)^{\frac{1}{k}} \\ a_1 b_1 + a_2 b_2 + \dots + a_n b_n \leq \sum_{i=1}^n a_i b_i \text{ or } \sum_{i=1}^n a_i b_i \leq \left(\sum_{i=1}^n a_i^h \right)^{\frac{1}{h}} \left(\sum_{i=1}^n b_i^k \right)^{\frac{1}{k}}$$

which is Holder's inequality.

As previously stated, let $h=k=2$ and Holder's inequality yields Cauchy's inequality

$$\sum_{i=1}^n a_i b_i \leq \left(\sum_{i=1}^n a_i^2 \right)^{\frac{1}{2}} \left(\sum_{i=1}^n b_i^2 \right)^{\frac{1}{2}}$$

Since $a > 0$ and $b > 0$, we may square each side without fear of introducing extraneous solutions to give the more familiar form of Cauchy's inequality

$$\left(\sum_{i=1}^n a_i b_i \right)^2 \leq \left(\sum_{i=1}^n a_i^2 \right) \left(\sum_{i=1}^n b_i^2 \right).$$

Conclusion

The twelfth or thirteenth year mathematics student may be bored with the repetition of certain mathematical methods. However, his interest and enthusiasm for new and more advanced mathematics is evidenced by the elementary functions and elementary analysis courses that are now appearing in the curricula of school programmes in the U.S.A. This article is presented in hope of renewing this student's interest in the inequality and in creating an awareness on the part of the teacher in what may be done at the school level.

The usual derivation of Cauchy's inequality may well be beyond the senior high school student's comprehension. However, young's

$$\text{inequality, } ab \leq \int_0^a f(x) dx + \int_0^b f^{-1}(x) dx,$$

may be derived geometrically and easily understood by this type of student. Interesting algebra provides Holder's inequality from Young's inequality and a simple substitution in Holder's inequality brings forth Cauchy's inequality. Although the derivations of Holder's inequality from Young's inequality and Cauchy's inequality from Holder's inequality may be somewhat lacking in rigor in the sense of equality in each case, Tolsted's original article on which this lesson is dependent (4) presents a rigorous proof. The case for equality as presented by Tolsted is basically simple and requires but little further investigation on the part of the teacher (student).

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Young folks corner

A Scientific Deed

S. A. Balezin and M. C. Pant

AS early as the dawn of civilization, man occasionally found in nature some of the chemical elements, among them such metals as copper, iron, silver and gold.

These metals, copper and iron in particular, have been so important in man's life that entire historical periods have been given their names, for instance, the bronze age and the iron age.

The discovery of each new element was a major scientific event, sometimes it turned out to be a virtual revolution in science as for instance, the discovery of the element radium at the end of the 19th century

By the end of the 18th century about 30 chemical elements had already been discovered. Scientists began to think if it were not possible somehow to classify the elements by the similarity of their properties. The first attempt to classify the elements was made by the famous French scientist A. Lavoisier. In 1789 he published his book *The Elements of Chemistry* in which he made the first attempt at such a classification.

In commemoration of the Hundredth Anniversary of the discovery of Periodic Law of Chemical elements



Mendeleev

By the similarity of chemical properties, he divided all the elements known at that time into four groups. In group 1, he included oxygen, hydrogen and nitrogen.

Thinking that heat and light were chemical elements he erroneously included these elements in group 1. In group 2, he included sulphur, phosphorus, carbon, chlorine and fluorine. The elements of this group were named (by him) "acid forming elements". Silver, iron, arsenic, bismuth, tungsten and zinc were called by Lavoisier "the group of metals". The oxides of calcium, barium, silicon, aluminum and magnesium were included in group 4 as he considered them to be individual elements. He called this group "earthly salt forming metals."

The importance of Lavoisier's ideas was in the fact that he had drawn attention to the possibility of arranging elements into groups by their similarity.

In 1817, the German scientist Dobereiner, Professor at Yen University, drew attention to the possibility of arranging the elements in triads on the basis of their close similarity. Thus calcium, strontium and barium are found in nature in the form of salts of sulphuric (sulphates), hydrochloric (chlorides) and carbonic (carbonates) acids. The sulphates of these elements are practically insoluble in water while the chlorides are soluble. The oxides of these elements dissolve in water forming strong alkalis.

Another such triad was formed by the alkaline metals—lithium, sodium and potassium which had been obtained in 1808 by the English scientist Davy by means of electrolysis from their melted chloride salts. Dobereiner made an interesting observation namely, that if the elements in the triad were arranged in the order of their increasing atomic weights, the atomic weight of the medium element was equal to half of the sum of the two extreme elements. Thus in the triad: calcium (4), strontium (87.6) and barium (137), the atomic weight of strontium namely, 88 is an average of the sum of the atomic weights of calcium and barium. He discovered the same regularity in chlorine, bromine and iodine. However, not all the elements could be arranged in triads and Dobereiner gave up further efforts to classify them.

As new elements were being discovered the need to classify them was felt ever more strongly. In 1857 D. Newlands, the English chemist, arranged the elements, beginning with hydrogen, in the order of their increasing atomic weights and discovered the recurrence of similar chemical properties for elements 1, 8 and 15. This was similar to

the recurrence of the 8th part in the musical octave. That is why he called this regularity the principle of the octaves. However, this simple regularity was observed only for some of the elements discovered at that time. Chemists were speculative about the Newlands' idea and he himself gave up further attempts at classification.

By the end of the 19th century, as many as 63 chemical elements had already been discovered. Each individual element was being studied separately from others.

The discovery of a new element was not linked with others and it was not possible to predict how many elements existed in nature as no common regularity had been found regarding their similarities or differences.

Figuratively speaking, the state of the science of chemical elements at that time could be compared to a box containing separate pieces of a remarkable but broken vase. These pieces could be arranged by weight, colour and shape. However, many of the pieces of this vase had been lost. To restore the vase, it was necessary not only to locate the place of each piece but also to determine its shape.

The German Scientist L. Meier had been quite close to solving this intricate problem when in 1864 he took the so-called specific atomic weights of the elements as their basic characteristic and obtained a periodically recurring curve related to the increase in the atomic weights of the elements. Arranging the elements in the order of their increasing atomic weights, Meier was confronted with the problem that the atomic weights of some elements failed to fit into his table. This resulted in the violation of the periodic recurrence of the chemical properties of the elements. At the very last moment when he was on the verge of discovering true periodicity of elements, he gave up his efforts.

It was then, that the Russian Scientist D.M. Mendeleev decided to tackle the problem. While a student at the Petersburg Main Pedagogical Institute, he took an interest in the various relationships between the properties of chemical elements. However, it took quite some time and a great deal of patient research before Mendeleev was able to solve the problems.

As a result of his 15-year study of the various physical and chemical properties of the 63 chemical elements known at that time, he accumulated an enormous amount of factual material. On a careful analysis of this material Mendeleev found the answer to the question, namely, what was the basic factor determining the chemical and physical properties of each element? He concluded that the atomic weight was the basic characteristic feature of each element determining its chemical, and some of its physical properties. Arranging the elements in the order of their increasing atomic weights and by comparing their properties, Mendeleev discovered a fundamental law of nature: "that the properties of bodies (elements) as well as the properties of combinations of elements are in a periodical dependence (or in terms of algebra, form a periodical function) on the size of the atomic weights of the elements."

With an enormous amount of factual data on the properties of each chemical element, Mendeleev began to arrange them in the order of their increasing atomic weights taking into account their common properties. Arranged by the size of their atomic weights the elements formed, in a natural way, a common system in which similar properties were periodically recurring after a certain number of elements. Similar elements formed groups in the vertical direction while the individual elements in these groups formed

periods in the horizontal direction. Thus the periodic system, or the periodic table of chemical elements as it is called today, was created. This system was, as it were, a graphical representation of the periodic law.

The initial version of this table was published on the 1st of March, 1869, i.e., 100 years ago.

In arranging the elements in his periodic system Mendeleev encountered many difficulties. Unlike his predecessors, Mendeleev was confident that he had discovered a new law of nature and that is why he was guided by this law in his further elaboration on and improvement of, his periodic table.

At that time the atomic weights of many elements were inaccurate. This accounted for the difficulties in making up the table. For instance the atomic weight of the element—berillium was estimated to be 14, while according to Mendeleev this place was already occupied by nitrogen with the same atomic weight. Either the periodic law was wrong or the atomic weight of berillium had been wrongly determined. According to its chemical properties, it should be between lithium and boron, but its atomic weight in this case would have to be 9.3. Bravely, Mendeleev deleted 14 and put 9 for berillium in the original version of his table.

Eighteen months later Mendeleev, proceeding from his law, changed the atomic weights of indium, cerium, uranium and others. He did this confidently believing in the correctness of the law he had discovered. He did not hesitate to change the experimental data if these disagreed with the table.

Mendeleev corrected the atomic weights not haphazardly, but on the basis of similarity and differences in the properties of the elements. For instance, the atomic weight of indium had been estimated as 75.6. Had it been correct, indium should have occupied

in the table the place which was occupied by zinc or strontium. Mendeleev corrected not only the atomic weight of indium but also its valency. Indeed, as Mendeleev predicted, a more careful verification of the atomic weight of indium proved it to be 114 while its valency was 3. On the basis of a theoretical conclusion only, Mendeleev corrected the atomic weights of 9 elements and all these corrections were later confirmed by further experimental data. When arranging the elements in his table Mendeleev discovered disagreement between adjoining elements; he inserted a blank claiming that this place belonged to an element yet undiscovered. Moreover, he predicted the physical and chemical properties.

One can very well imagine the storm of indignation that was caused among scientists by these corrections of atomic weights and predictions of new elements on such a "shaky basis" as a periodic law. Such sentiments were expressed at the time by the German scientist Meier.

Mendeleev did not give up, but bravely continued his work on improving the table. To him all the links and the entire architecture of the 'remarkable broken vase' with the missing pieces, was already quite clear.

Subsequent research confirmed his predictions. It took less than 5 years for the French Scientist Leacock-de-Buabodran to discover one of the elements predicted by Mendeleev. He called it gallium after the name of his mother country. The specific gravity of gallium as found by Leacock disagreed with the figure predicted by Mendeleev. All credit should go to the courage and insight of the Russian scientist for, when he learnt of the results of Leacock's work, he wrote him explaining that he must have made a mistake in his calculations, thus obtaining a wrong result in determining the specific gravity of gallium.

The French scientist was extremely surprised and even became indignant after all he was the only chemist in the world who was holding the new element in his hands and it was he who had opportunity to study its properties, just to think of it the Russian chemist had ventured to indicate to him the imprecision of his experiment, and that only on the basis of some theoretical thinking even without having actually seen the element. However, it was Mendeleev who was right. When the element was more thoroughly separated from impurities the specific density of this element was found to be equal to that predicted by Mendeleev. Greatly impressed by this Leacock later became a true worshipper of the genius of the Russian scientist.

Mendeleev predicted the existence in nature of 11 hitherto unknown elements and described the basic chemical and physical properties of three of them.

The first of the elements predicted by him was discovered, as we know, by Leacock-de-Buabodran in 1875. Shortly after this in 1879 L. Nilson, the Swedish chemist, discovered another element and called it scandium in the name of his motherland. The properties of this newly discovered element coincided with Mendeleev's predictions with surprising precision. Amazed by this, Nilson wrote that "it was a graphic confirmation of the ideas put forward by the Russian chemist enabling one not only to foresee the existence of a simple body (an element) but also to describe in advance its main properties."

The third of the elements predicted by Mendeleev was discovered in 1886 by the German scientist Winler who gave it the name of germanium. The properties of this newly discovered element, as in the case of the two preceding elements, agreed with the properties predicted earlier by Mendeleev. Truly, it was a triumph of the Periodic Law.

However, later on as new discoveries in the field of chemistry and physics were made, the validity of this law was subjected to many new trials. Thus, in the 80's Reeli and Ramsey (English scientists) discovered that atmospheric air contained substantial quantities of an element which they named argon. This element proved to be chemically inactive; where did it fit into Mendeleev's periodic system?

Under the Periodic Law, the chemical properties of the elements change with an increase in their atomic weights. But this element was chemically completely inert. Soon after this the gas helium, similar to argon, was found in nature.

Then Ramsey assumed that in nature there must exist a whole group of such elements which in the periodic table must be placed between the most reactive metals and the most reactive non-metals. Indeed, very soon two more inert elements were discovered. In the search for new inert elements scientists were already being guided by the Mendeleev Law. "In the way in which our teacher Mendeleev did it, I described as far as it was possible, the anticipated properties and expected relationships of the element", wrote Ramsey

With the discovery of the group of inert gases the periodic system of chemical elements has become still more structurally refined. However, the Periodic Law was still to go through further trials.

The end of the 19th century witnessed the discovery of radioactive elements. It was found that the atoms of radium, for instance, spontaneously disintegrate with the formation of new elements. Thus the entire concept of the indivisibility of the atom was disproved. The end product of the decay of radium is lead. In the periodic system there are only 11 places between radium and lead; while radium decays,

more than 30 new elements are formed. How can these 30 elements be placed in 11 squares? Up to that time Mendeleev and his supporters thought that each place in the periodic system served as if it were a room in a large flat which is inhabited only by one resident (one atom of the given element) who is not entitled to pass from one room into another. They had to admit that these elements had atoms with different atomic weights. In this case one room (check) could admit several dwellers i.e. in one room there could be placed several atoms with different atomic weights but with the same chemical properties. If it were so then what was the main determining factor for a chemical element?

This thesis brought under attack the entire building constructed by Mendeleev, based on the assumption that the atomic weight of an element is the main factor determining the chemical characteristics of the element.

However, this difficulty was shortly overcome.

In 1913 while studying the complex structure of the atom the young English scientist Mosley discovered that the positive charge of the nucleus is equal to the ordinal number of the element in the periodic system. This discovery threw a new light upon Mendeleev's Periodic System. The charge of the nucleus, rather than the atomic weight, determines the chemical properties of the elements.

The Periodic Law had been discovered long before the complex structure of the atom was known. The mass of the atom is associated with the charge of the nucleus and increases in relation to the increase of this charge. But this sequence is not always followed by the elements. However, the great chemist had even made allowance for this in his table. He had allowed three "exceptions" in his table putting heavier atoms before the lighter ones. For instance,

tellurium whose atomic weight is 127.6 was put before iodine whose atomic weight is 126.9. Mendeleev made these exceptions from his law on the basis of the properties of these elements. But he had no data to account for these "exceptions".

In the light of Mosley's discovery the reasons for these digressions became apparent. In fact the charge on the nucleus of the iodine atom was greater than that on the nucleus of the atom of tellurium.

What was the explanation? Subsequent discoveries solved this mystery too.

Rutherford and Soddy working in England assumed that radioactive decay results in the formation of new elements with similar charges but with different atomic weights. That is why the same square of the Periodical system admits dwellers with the same characteristic elements (with similar chemical properties) but with different atomic weights. Such atoms were called isotopes.

That is why in the decay of radium more than 20 atoms can find room in 11 squares.

Further research showed that almost every chemical element has its isotopes.

Mosley's discoveries stimulated a further search of new elements. The first element in the Periodic System namely, hydrogen has an ordinal number of 1 (the charge of the nucleus is equal to 1), while the last element known at that time namely uranium was element number 92. Consequently between hydrogen and uranium there had to be 92 elements rather than 63 as was known by the end of the 19th century.

And indeed, a further search for these unknown elements whose places in the table were not filled was crowned with success. By the middle of the 20th century all the vacant places in the Periodic System had been filled. Thus every prediction of Mendeleev was brilliantly justified. Throughout the entire history of civilization only 63 chemical ele-

ments had been discovered while after Mendeleev's discovery of the periodic law it has taken less than half a century to find about 30 new elements. The compass for these discoveries was the Periodic Law. However, the role of the Periodic Law does not end there. Mendeleev predicted that the Periodic System did not end at the 92nd element, uranium. There had to be trans-uranium elements and this prediction has also become an established fact. Today not 92 but as many as 104 elements are known. It is true that the trans-uranium elements have been artificially created in laboratories while only some of them have been discovered in insignificant quantities in nature. However, in this case too, the guiding light for artificial preparation of trans-uranium elements has been the Periodic Law. In the lecture which he delivered in London on the 23rd of May, 1890 at the invitation of Faraday Society, Mendeleev said "the years to come would not threaten the law; on the contrary, the years to come would contribute to its development and improvement." "Before the discovery of the Periodic Law", he said, "the simple bodies (elements) represented only disconnected accidental phenomena of nature. There was no reason (in those days) for anticipating the discovery of any new simple bodies while those newly discovered were an unexpected novelty in their properties. The Periodic regularity gave the first opportunity of seeing the yet undiscovered element at such an enormous distance which hitherto the chemical vision yet unarmed with this regularity failed to see."

The Periodic Law has overcome all the difficulties in its way and today is the basis on which all modern science is developing.

Academician Fersman wrote this on the significance of the Periodic Law. "The world of substances which surrounds us can be represented in the form of an enormous Men-

Mendeleev table unfolded according to the periods and broken down into individual lengths. In accordance with the Periodic Law new theories will emerge and die, brilliant generalizations will replace our outdated concepts, greater discoveries will eliminate the discoveries of the past and will open up a new horizon yet unseen in its newness and width. All these will come and go but the Mendeleev Periodic Law will live on, develop and

improve."

A hundred years ago Mendeleev had made one of sciences greatest discoveries which he bravely protected and defended thus performing a truly scientific deed.

The intricate puzzle of the 'remarkable broken vase' has been solved and the vase restored as one of the greatest miracles of nature.

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Prof. Fred Hoyle FRS

PROF Hoyle received the Kalinga Prize at a ceremony in New Delhi on February 22.

The Kalinga Prize, for the popularisation of science, was instituted in 1951 by the Indian industrialist Mr. B Patnaik. It is awarded annually by an international jury under UNESCO sponsorship. Others to receive this prize earlier are Sir Julian Huxley, Earl Russell, Lord Ritchie-Calder and Mr. Arthur Clark

In India, Prof Hoyle is best known for the Hoyle-Narlikar theory on the problem of gravity which he and his Indian colleague, Dr J V Narlikar, propounded in 1964

Prof. Fred Hoyle is Plumian Professor of Astronomy and Experimental Philosophy at the University of Cambridge, and Director of the University's Institute of Theoretical Astronomy. He is a Staff Member of the Mt. Wilson and Palomar Observatories in California (U.S.A.) and a visiting Professor of Astrophysics at the California Institute of Technology.

His work covers a wide field, an outstanding part of it being concerned with stellar structure. In the summer of 1964 he, Dr. J.V. Narlikar, presented a paper to the Royal Society in which a new approach was proposed to the problem of gravity, and in 1968 the two published the results of a new investigation of electro-dynamics. Some years ago Prof. Hoyle became widely known as a leading exponent of the steady-state theory of the universe; he later put forward a modification of his views before the British Association for the Advancement of Science and dealt with the subject further in the George Darwin Lecturer which he gave for the Royal Astronomical Society in November 1968.



Prof Fred Hoyle FRS

Post Graduate Research

Prof. Hoyle, a Yorkshireman, was born in 1915. He graduated at Emmanuel college, Cambridge, being scholar, prizeman and exhibitioner, he carried out post-graduate research as a Fellow of St John's College. Shortly before world War II, he and Dr. R.A. Lyttleton promulgated their theory of the major importance, in galaxies' development, played by the capture of interstellar material by stars.

During the war Prof. Hoyle was employed for a period by the Admiralty on radar development, but managed to continue his own research in his spare time. He returned to Cambridge, and was from 1945 University Lecturer in Mathematics until receiving his

professorial appointment in 1958. He remains a Fellow of St. John's.

At the Cambridge meeting of the British Association in 1965 Prof. Hoyle reviewed recent research which appeared, he said, to indicate that the universe must once have been in a higher state of density than it was today; he suggested a modification of his steady-state theory, building up two pictures of the universe—first, a finite universe in oscillation; secondly (a view based on investigations by himself and Dr. Narlikar) an infinite universe with oscillations in various finite regions.

In his lecture to Royal Astronomical Society in October 1968 Prof. Hoyle suggested that the universe may be sustained by the creation of matter within the massive galaxies and quasars and, drawing on his and Dr. Narlikar's gravitational theory, postulated "gravitational collapse" which, instead of destroying its substance, would reverse its force and result in the creation of new material. These observations could lead to a new conception in Physics and also to a modified picture of a "steady state" universe.

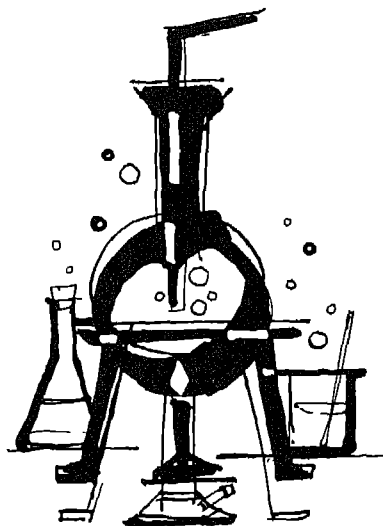
Origin of Planets

Another recent investigation by Prof. Hoyle with Dr. Wickramasinghe, a staff member of the Institute of Theoretical Astronomy, has led them to propound a theory of the origin of the planets. Concurring with Alfven of Sweden, they believe that planetary material left the contracting sun during an early stage of its evolution with a transference of the sun's rotational momentum—and through calculations taking 25 hours on the fastest available computer, they have studied the chemical history of the planetary material from the stage when the disc left the sun's equator to the time when the cooling of the gas led to the formation of particles which built up into planets.

Prof. Hoyle, who was elected a Fellow of the Royal Society in 1957, has written a number of books including other subjects besides cosmology. He has also written space fiction in the form of television and stage plays.

He married Barbara Clark in 1939; they have a son and a daughter.

By Courtesy: British Information Services



New Trends in Science Education

INTRODUCTION of biology, physics and chemistry as separate disciplines in Middle Schools classes in place of general science has become the current topic among the science teachers. It is but natural to discuss such matter when such radical changes are brought about in the curriculum. Let us have a close look at the General Science Course for VI class as followed until recently and the botany portion prescribed

Teaching of Biology as a Separate Discipline

MRS. PATHROSE

Biology Teacher, Mother's International
School, New Delhi

for the same class and see whether we have taken a step better or for the worse.

Curriculum

In our school for the general science we were following this book 'Adventures in Tropical Science for Juniors, Book 4' in Class VI. The topics given in the book are: air, heat, light, sound, soil, factories of a plant, fungi, some familiar wild flowers, raiders of the night (mosquitoes), household pests (fly), spiders, ants, and watch the birds. The aim of General Science course was perhaps to make the children aware of the Inter-relationship between physics, chemistry and biology. But one fails to understand how this aim could be achieved by inserting in the same book, some physics topics, some chemistry topics and some biology topics which do not have any direct relationships among themselves. Even if we take the biology portion alone into consideration we can see that there is no sequence or gradation. Without the child understanding what a cell is, he is told in the topic 'factories of a plant' that there are many rooms called cells in a leaf and that there are machines

which can prepare food for themselves and also for us. Just in the form of a story, the child is told about the manufacture of starch in the leaf. The cellular structure of the root and the stem is not mentioned anywhere in the chapter but it is mentioned that there are long pipes in the stem which help in the upward and downward transportation of food. This may even lead the child to think that there are no cells in the stem and the root. When we start the next topic, we jump from the flowering plant, immediately into the fungi and then again go back to some wild forms of flowering plants; when leaving the plant kingdom completely. We switch on to the animal life. This, I don't think, is a logical approach to the study of science.

Now let us see what the new curriculum started by the NCERT as a project is. I have been in touch with the Botany course prescribed for Class VI for the last two and a half years. I find that enough stress has been on the systematic approach to the Science. The child has to acquire a good deal of knowledge each topic which helps him to understand the next topic and is based on the principle of the previous topic. For example, when a child has to understand the idea of tissue, he ought to know what the structure of a cell is. Now a question may arise as to why should this young child of ten years be told about the cell or tissue, when we the teachers had seen a cell only in our Intermediate classes. If a child does not know what a cell is, what a tissue is, and what tissues are present in the root, stem, leaf etc. how can the child get a real understanding when we discuss the functions of the stem, root, leaf etc. From the cell we pass on to the seed. As the plant life has to start from a seed, it is a quite a logical approach to start with the seed and its germination and then starting from the root dis-

cuss the other parts such as stem, leaf, flower and fruit

Equipment

Another point which the new curriculum demands is the use of equipment for demonstration and laboratory work. Very often we take it for granted that the children know many of the simple things that come across while teaching the subject and so, we reduce our teaching to simple narration. Here I should mention a very interesting fact. I saw the radical and plumule of a seed, for the first time in my life when I was doing my practice teaching during the training period after my degree course. The knowledge which we received was so theoretical and examination-dominated that such simple things were never shown in the class, nor did the students bother to search for the truth of the acquired knowledge. In this connection I would like to refer to another experience of mine. A trial is on in our school to find out whether the course prescribed for sixth class could be taught to the fifth class also. We have in four sections—two in fifth class and two in sixth class. I was taking both the sections of sixth class and one-section of fifth class. The other Section of fifth class was taught by another teacher. When we are teaching about the fat contents of the seed, I simply showed them some mustard oil and asked them from where the oil was extracted. Of course, many children suddenly answered that it was taken out of *sarso ka beej* (mustard seeds). I was satisfied with this answer and I told them about other seeds like til, ground nut and coconut which also contain a good amount of oil. But in the other section of class V, the teacher adopted another method, which of course is mentioned in the textbook i.e., to take some mustard seeds and crush them on a white sheet of paper so as to watch the

oil streaks. When all the four classes were tested on this particular topic, in the class where the students were taught by the other teacher, the result of evaluation was cent per cent whereas in all the other three classes the result was between 60 to 80. Here we see that if the children are allowed to handle the things and to make observations by themselves, it is very easy for them to remember it. Many other similar experiments are presented in the book which can easily be performed by the students themselves, of course, under the guidance and supervision of the teacher. Some such laboratory work are examining the parts of a plant and those of a flower, observing the cells of an onion peel under the microscope, taking cross section of root, stem and leaf and observing them under the microscope. In short, no topic is such where either a demonstration by a teacher or individual experiment by the child is not possible.

Field work

Excursions and field work are other important features of the new curriculum. Some of the topics can very easily be taught in a field or in the school compound much better than in a classroom. For example, take the case of teaching the difference between cultivated plants and wild plants. Instead of the teacher lecturing in the class, if she can take the children into the school compound itself and show the plants grown in the school garden and the bushes growing by themselves in nearby places, the child would easily understand the difference between the two. If they are helped to make a few collections of each category, then the process of learning becomes much effective. Making them note the difference between herbs, shrubs and trees is another instance where field work could be utilised for better teaching. Similarly, kinds of leaf arrangements inflorescence

etc. could be taught effectively in the field as they would then be getting direct experience by handling the objects themselves. In a school compound like ours it is very easy to get all the kinds of arrangement of leaves, venations etc. We have the convenience for adopting such methods of teaching. However, I have not been utilising this opportunity for teaching all those topics due to certain discipline problems which I shall discuss at the end.

Daily life of the child

The link between the text material and the requirements of life is another feature of the new curriculum. In the very beginning the children are made aware of the importance of plants. By telling them about the importance of plants, we are able to cultivate in them a sort of interest in plants. This kind of interest, taking root in their minds at such early stage may lead to good behaviour. When they realise the importance of green plants, their instinct in destroying the plants will be lost and they will start taking care of the plants. The topics on irrigation, fertilizers and preparation of the soil are so directly related to the needs of the present Indian conditions that they help the children to get a good knowledge on farming. Similarly by helping the children to handle small flowers of mustard and separate their small sepals, petals, stemens and a needle, and to keep them pasted on a sheet of paper in a systematic way, we are perhaps preparing the future doctors for the operation theatres in the hospitals.

Reaction of the Pupils

Now I will come to the child's reaction to the new system. From my own experience I can say that the children are much more enthusiastic and interested in the 'new subject' than they used to be in the general

science class. This may be because the General Science Course did not have any scope for giving the students a chance to do things themselves. But the present one provides them enough chances which automatically helps them to take more interest in the subject. In the classrooms I am always welcomed by a set of students who approach me with question as "Madam, what experiments are you going to do today?" or "are we ourselves going to do something?" By inserting the leaf in between the two cut pieces of a carrot, one of my students from the first batch, could prepare a better cross section of leaf than I could this is really a creditable achievement for a class child. Reports from the parents that their children are most of the time busy in drawing botanical diagrams, growing seeds, experimenting with coloured water, starch and iodine, how much interest the children are taking in the subject. Even the results of the examinations as indicated below are quite encouraging. In the examination held in 1967-68, in class VI A, out of 22 students only two failed and the highest mark obtained was 89. In the B. section of the same class, out of 24 who appeared only two failed and the highest mark obtained was 88.

Problems of the New Project

Now let me come to the problems related to the new system. I do not mean that by the introduction of botany as a subject we have solved all our problems and I do not have any classroom difficulties. When the course was introduced in our school in the year 1966, we felt the need for a double period (for pupil activities) and one free period for the teacher before the practical period so as to enable the teacher to arrange things before the children reached the class. Because of this reason, the need for a separate well-

equipped laboratory arose, and ours being one of the experimental schools, we were supplied with all these facilities. Even when all the facilities are given, unless the teacher is fully informed to of the new method and the teacher is fully informed of the new method and the change in the outlook towards the subject, I don't think a teacher could be successful. The summer course arranged by the N.C.E.R.T. and the 'teachers' guide' provided by them were quite useful to me in getting line with the new method of teaching.

Discipline in the Classroom

Another problem relates to the maintenance of discipline in the laboratory and in the field. In the practical class, one teacher has to attend to so many students at a time. Everyone needs attention, especially when they work with the microscope. All are excited and everyone is anxious to show his specimen. As a result, there would be so many calls at a time. But when you run from one place to another you would be simply disappointed when you look into the microscope, as there would be only very thick sections. But now I realise that there is no need for any disappointment. It is only the beginning of a work; they are just learning the method and are not yet experts even at the first attempt. My experience shows that from the root when they reach the stem, they do better. Similarly, while going for the field work, the attention of some of the students is diverted from the objects of study to other objects of their own interest. Many a time it becomes a problem for the teacher to control them. However, this I feel, is a temporary phenomenon, and the children will gradually come to the point of interest when they get experience of a number of such field work.

The Slow Learner

Another problem relates to the weak students. Even if the majority of children is interested, and doing fairly well in the class we have to worry about the weak ones. They may not be weak in biology only. They may as well be weak in other subjects also. Such cases would be there even if the general science course is followed. Therefore the defect is not with the course but it is due to several other factors like the family circumstances, low I.Q. etc. which the teacher has to deal with separately.

From the above assessment of the advantages and disadvantages of the new system, it is clear that the advantages are more than

the disadvantages. The new system has a better scientific approach. It inculcates interest in the child and helps develop the child's ability to analyse and understand the objects in a systematic way. I have heard the story of a person who wanted to learn a new language. He says, 'The best way to learn a new language is to fall in love with a girl who knows that language and within a short period you can be the master of that language.' The new system, in fact, leads the children to such a position enabling them to have direct access to the objects of their study. I would, therefore, strongly recommend the new system for introduction in all the schools in India.

The Teaching of Chemistry as a Separate Discipline

MISS LALITA ARORA

Chemistry Teacher, Government Girls Higher Secondary School,
Sarojini Nagar, New Delhi

RADICAL changes have recently been introduced in India with regard to the teaching of science in our schools. The new system of teaching chemistry as a separate discipline from class VII has been adopted in our school. I would like to discuss the advantages of the new system in the teaching of chemistry and about the difficulties we experienced at the beginning when we started this new system.

In the previous years sciences were taught as separate subjects only from the 9th class but now according to the NCERT-UNESCO project the chemistry is begun in class VII itself. I myself did not hear about the word chemistry before I came to the 9th class.

But a pupil in the 7th class now not only has heard about chemistry but he also studies it. In the old curriculum of the general science in the 7th class there is hardly a lesson on chemistry although a little of biology and physics were taught. A student's knowledge in the 7th class about substances, their structure, composition and changes that take place in them was almost nil. But now the pupil knows there are certain particles which make up a substance and the changes it can undergo and other such details about substances. Again a pupil knew very little about oxygen and hydrogen except that oxygen was necessary for respiration and hydrogen was the lightest

gas which was used to fill balloons. But a student of the same class taught in the new way is able to tell the symbol, the atomic weight preparation, physical and chemical properties and uses of hydrogen and oxygen. This would give one an idea of the gap between the old and the new curricula. Water and solutions are also topics included in the new material. A book used in general science of the 7th class does not mention about various solutions and water. Once the pupil know about solution and water it is easy to teach oxides, acids, bases and salts. A pupil starts studying a lesson only after getting a background of it in the previous lesson.

Chemistry is a subject which can be taught only by experiments and demonstrations. It can never be taught only with a black-board and chalk. Demonstration is an experiment for performing by the teacher in front of pupils. Experimentation means testing a hypothesis.

All this work requires prior preparation by the teacher. Thus the load of work of the teacher is increased. Besides the increase of work there is lack of time and an unsuitable time-table. We usually get about 15 periods a week as leisure periods. But half of these are taken up when the teacher goes as a substitute in place of the absent teacher. Thus on an average a teacher would get only one free period in a day. In this 35 or 40 minutes the teacher has to think about so many other things in addition to corrections and home assignments, writing a diary and sometimes dealing with stock registers, class registers or receipt books. Any preparation for the next class could be done only during this period. These factors stand in our way of keeping ourselves up to date in our work. But with a little effort these problems could be solved at least partially. We could at least request our principals not

to give us work as substitute teachers. We can also request for two continuous periods which could be utilised for demonstrations and experiments. We can also request for a free period before the double period to be used for setting up of apparatus and equipment.

Another difficulty is that the room may not be provided with enough furniture and may not be suitable for our work. One more difficulty is the lack of apparatus. This has been solved to an extent by a special grant of Rs. 3,000/- by the Directorate of Education. Any lack of apparatus we try to make up by improvisation. The medium of instruction in schools is Hindi. The teachers often find it difficult to remember the terms in Hindi but with practice this difficulty would be got over.

Through experience I have found out that what appear to be very difficult become less difficult in the next session and I have faith that we could overcome our difficulties in the course of time. I may be permitted to quote an instance from my own experience. While teaching valency and molecular formula to the 7th class for the first time I thought that this topic would be too difficult for the pupils. But this year I made it a little easy for the pupils to understand valency and molecular formula at the beginning of the lesson on structure and composition of the substances.

Chemistry is not confined to the classroom and textbooks. It has its own place in everyday life. Thus a pupil taught in the new way would know that chlorine is used to purify water and would also know the use of Potassium Permanganate against germs. He would also know that oxygen is good supporter of combustion. He would use this knowledge in daily life. In case of fire the pupil would immediately prevent it from getting of oxygen by covering the burning

material with something.

Though under the new programme, physics, chemistry and biology are taught separately the pupils would know the relationship between these subjects when they study about crops in botany they have to study about fertilizers too. Other phenomenon in which knowledge of several subjects is necessary are photosynthesis in plants, conduction of food materials in the stem and the composition of seeds

I am glad to say that parents of pupils studying chemistry under the new Project feel very happy about it. They are happy to see their children busy with a set of fertilisers or with different kinds of soils or with different metals. The children collect such things during their visit to place and by other means.

Response of the pupils

The best method of learning a thing is actually by doing it. In Chemistry classes first the children do some activities or observe something before they learn the behaviour and attitudes of pupils change. They start thinking in a logical way. They are always eager to know the 'why' and 'how' of a thing and sometimes the curiosity is the main reason for temporary indiscipline in the

class. Their vocabulary has also increased. They also become practical in their behaviour. They also express their interest in various ways. The number of pupils who pass in evaluation test is also on the increase. Previously, in the General Sciences classes only 85 per cent of the pupils could pass. But in the 7th class in 1967-68 the percentage has increased to 95.

The Role of NCERT and UNESCO

We are receiving a lot of help from the NCERT in the teaching of the subjects in our schools. We are guided by the Department of Science Education and by the UNESCO experts. They hold regular seminars in which guidance materials are distributed and they make us do all the experiments that we expect to do in a class or we expect the children to do. We are also shown film-strips and other teaching aids. This gives us confidence in our teaching through demonstration and experimentation. We are also taught how to improvise small tools like fixing a platinum wire in a hot melted glass rod, or burning sulphur in pure oxygen with a beautiful blue flame. The experts visit our schools and discuss with us the problems and suggest ways of overcoming them.

Study Group in Mathematics Jadavpur University

THE Study Group in Mathematics Jadavpur University, Calcutta-32 formally came into existence in October 1967 with the object of preparing curricular materials in Geometry. The syllabus for middle schools being already finalised, the first task of the Group was to prepare the curriculum guides for classes V, VI, VII. The curriculum guides are intended for teachers and prospective authors of textbooks. In each of the curriculum guides, (consisting of a number of units), the treatment in each unit was split up broadly under the following heads: (i) aims and objects of the unit (ii) method of introducing concepts and subconcepts (iii) classroom and student activities (iv) understanding and skills to be achieved (v) exercises and (vi) the list of symbols, concepts and vocabulary in each unit. These guides were discussed with the other Group at Bangalore. In the meantime, textbooks were written by the Bangalore Group and they were discussed with Jadavpur Group. The content of the course in geometry is largely based on the notions of 'transformations'. Apart from this, the curriculum envisaged includes the ideas on order relations, and orientation. It is these ideas that distinguish the curriculum presented in the books from the traditional one, dominated by the Euclidean style. As these concepts are different from what have been followed hitherto, it was felt to prepare the teacher's guides corresponding to every text book, and this may, it is believed, help in unfolding the essence of what is styled as new mathematics. The curriculum guides have also been tried out at the Summer Institutes held at Jadavpur University in the summer of

1968 and are being recast in the light of the responses of the participants of the Institute. At present, the teacher's guides are being prepared with an eye to illuminating the difficult parts of the syllabus. For background study, a number of well-known books, journals and articles have been referred to in the teacher's guides and it is hoped that these will enable the teachers to form a clear exposition of the materials to be taught. A note on the books, touching briefly on the topics in some of the books, has also been appended to in the teachers's guide. The teachers' guide also mentions the names of instruments that are essential for necessary class-room activities that should be so geared as to elicit 'active learning' and 'discovering' the ideas by the students themselves.

The group consists of four teachers of Universities and four teachers of schools most of whom have been associated with the Summer Institute.

NCERT Mathematics Study Groups

J.N. Kapur, Indian Institute of Technology,
Kanpur*.

The National Council of Educational Research and Training took some steps to improve the teaching of mathematics some five years ago .

- 1 It set up a panel of distinguished mathematicians to write model text books for schools and

* Prof. J N Kapur is the convenor of the Coordinating Committee of five Study Groups in Mathematics.

- 2 Organised the first Summer Institute in school mathematics for school teachers in 1963.

The panel produced the following five books:

- 1 Insight into Mathematics—I by J.N. Kapur and K. Kapur (In Press).
- 2 Teachers Guide to Insight into Mathematics-I by J.N. Kapur, 1968
- 3 Algebra for Secondary Schools by I.N. Sinha (In press)
- 4 Trigonometry for Secondary Schools, by M.K. Singal and A.R. Singal (in Press)
- 5 Elements of Probability by S.K. Gupta, published in 1968.

During the past five years, 62 Summer institutes have been held in which over 2700 secondary school teachers have been trained in new ideas and techniques in mathematics.

Setting up of Study Groups

The NCERT has recently set up five study groups in mathematics as part of their programme to evolve comprehensive curricula in all science subjects and in mathematics. This was decided as a result of recommendations of a conference of scientists convened by the Council in April 1966 under the Chairmanship of Dr D.S. Kothari. The five study groups are located at:

- i) Central College, Bangalore with Prof K Venkatachalienger as Director.
- ii) Baroda University with Prof. U.N. Singh, as Director.
- iii) Hans Raj College, Delhi with Shri Shanti Narayan as Director.
- iv) Rajasthan University, Jaipur with Prof. G.C. Patni as Director.
- v) I.I.T. Kanpur with Prof. J.N. Kapur as Director Convener.
- vi) Jadavpur University with Dr. D.K. Sinha as Director.

The convenor's group has one reader, two lecturers and two schools teachers as full-time members while the other group have one full time reader and four or five part time teachers from schools and colleges. The first five were set up in October 1966, and the last in 1967.

The Coordinating Committee of the Study Groups decided to undertake the following three projects.

- i) Elementary School Mathematics Project (E S M P) for developing curricular materials for classes I-IV.
- ii) Algebra Project (A.P) for developing curricular material in Algebra (including arithmetic) for classes V to VII and VIII to X.
- iii) Geometry Project (G.P.) for developing curricular materials in Geometry (including coordinate geometry and trigonometry) for Classes V-VII and VIII to X.

The first was entrusted to the Kanpur group, the second was to Baidoda, Delhi and Jaipur Groups, and the third to the Bangalore and Jadavpur groups. It was also decided that work for classes V-VII should be based on knowledge of present primary curriculum only.

The Elementary School Mathematics Project

The Kanpur Groups has so far produced the following materials

- i) A Handbook for teachers in mathematics for primary classes—Part I (for class I)
- ii) A Handbook for teachers of mathematics for primary classes Part II—(for class II)
- iii) A Handbook for teachers of mathematics for primary classes Part III—(for class III).

- iv) About 100 charts as aids to teaching of E.S.M.
- v) About 60 models as aids to teach E.S.M.
- vi) Some aspects of School Mathematics —I: A cyclostyled volume of 305 pages.
- vii) Some aspects of School Mathematics —II: A cyclostyled volume of 402 pages.

The target of the Group is to complete the Handbooks for teachers for classes I-IV and produce a standard kit of models and charts for schools by June 1969. Thereafter it will undertake the preparation of standards texts, work books and teachers guides.

It is hoped that all the materials prepared by the Study Group will be available in English and Hindi by December 1969 and the translation in other languages will be done soon after.

The Kanpur Study Groups has also organised many training programmes for mathematics teachers of the region.

These training programmes were based on the above materials produced by the Study Group and some books written by the author.

The Algebra Project

The Study Group at Jaipur has already produced textbooks for classes V, VI and VII. The group at Baroda is producing an integrated textbook for class V. The three text books and teachers guides for these classes are expected to be ready by June 1969.

The Geometry Project

The Study groups at Jadavpur and Bangalore have produced teachers guides and textbooks for classes V, VI and VII. These have been tested in schools in Bangalore and Calcutta and the feedback has also been obtained from the participating teachers in

the Summer Institute at Jadavpur. These books have also been discussed with the participants in the workshop in school mathematics held at IIT Kanpur and attended by representatives from eleven states. The textbooks and teachers guides for classes VIII —X are expected to be completed in 1969.

The approach used in these books is of motion or transformation. The object is to enable the children to have a rich experience of symmetry considerations and to lay the foundation for a later axiomatic development.

There was a conference on school mathematics organised in the last week of June 1968. The members of the study groups participated in this conference. Some foreign delegates were also present.

National Workshop on School Mathematics

In December 1968, representatives of state insitututes of education from Delhi, U.P., Panjab, Rajasthan, Madhya Pradesh, Gujarat, Maharashtra, Mysore, Tamil Nadu, Kerala, Andhra Pradesh met at IIT Kanpur to discuss the ESMP and GP materials. On the whole, the materials were received with enthusiasm and the representatives agreed to implement these in their states.

The Future Programme

It is intended to try out the materials developed in a few schools in 1969-70, and to improve these in the light of the feedback received. From these trials the books would be revised and translated into Hindi.

During the course of their work, the Study Groups have had the benefit of discussions with Mr. B Brared, Unesco consultant with the NCERT and Dr. Routledge and Mr. Boys from Britain.

Summer Science Institutes 1969

DURING the period 1963-68, the University Grants Commission, in collaboration with the National Council of Educational Research and Training and United States Agency for International Development/ National Science Foundation, organised at various universities 233 summer institutes in science and mathematics for teachers from high/higher secondary schools/PUC/Intermediate colleges, attended by nearly 9,000 teachers in mathematics, physics chemistry and biology. The number of institutes held during this period and the enrolment at the institutes are given below.

The total number of American consultants associated with the academic programme of the institutes was 397.

Programme for 1969

During 1969, it is proposed to organise 58 summer science institutes under the above programme from secondary schools/PUC/Intermediate and Training Colleges:

Biology	11
Chemistry	18
Physics	15
Mathematics	14
Total	58

Year	No. of participants				Total
	Mathe- matics	Phy- sics	Chem- istry	Bio- logy	
1963	34(1)	43(1)	38(1)	39(1)	154(4)
1964	169(4)	170(4)	148(4)	153(4)	640(16)
1965	616(16)	488(13)	464(13)	261(8)	1829(49)
1966	490(12)	468(12)	410(11)	308(8)	1676(43)
1967	747(15)	572(16)	580(16)	482(12)	2381(60)
1968	646(15)	594(17)	612(16)	450(13)	2302(61)
Total	2702(63)	2335(63)	2552(61)	1693(46)	8982(223)

(The figures in brackets indicate the number of institutes).

Location and Duration of Summer Institutes

<i>Sl No</i>	<i>University</i>	<i>Institute Dates</i>	<i>For Teachers From</i>	<i>Director & Location</i>
1	2	3	4	5
BIOLOGY				
1. Ranchi University	9 June-19 July	Assam, Bihar, West Bengal, Manipur, Tripura, Nagaland and NEFA	Professor K.C. Bose, Department of Zoology, Ranchi University, Ranchi.	
2. Meerut University	12 May-21 June	Uttar Pradesh	Dr V P. Agarwal, Principal, D.A.V. College, Muzaffarnagar	
3. Agra University	12 May-31 June	Uttar Pradesh and Delhi	Dr. C.P. Singh, Department of Zoology, Agra College, Agra	

Location and Duration of Summer Institutes—(Contd.)

<i>Sl. No.</i>	<i>University</i>	<i>Institute Dates</i>	<i>For Teachers From</i>	<i>Director & Location</i>
1	2	3	4	5
4. Punjab University	2 June-12 July	Punjab, Haryana, Chandigarh, Himachal Pradesh and Jammu & Kashmir	Professor G.P. Sharma, Department of Zoology, Punjab University, Chandigarh.	
5. Bombay University	1 May-11 June	Bombay City and Gujarat	Professor T.G. Khubchandani, Principal Jai Hind College and Basantsing Institute of Science, 'A' Road, Church Gate, Bombay.	
6. Ravishankar University	12 May-21 June	Madhya Pradesh and Rajasthan	Dr. R.C. Agnihotri, Department of Botany, Government Science College Raipur (M.P.)	
7. Poona University	28 April-7 June	Maharashtra and Goa	Professor P.S. Karekar, Department of Zoology, Fergusson College, Poona.	
8. Marathwada University	1 May-10 June	Maharashtra	Professor K.B. Deshpande, Department of Botany, Marathwada University, Aurangabad.	
9. Andhra University	19 May-28 June	Andhra Pradesh and Orissa	Dr. B.S. Siva Rao, Department of Botany, Andhra University, Waltair.	
10. Madras University	5 May-14 June	Madras, Mysore and Andaman & Nicobar Islands	Dr. P.J. Sanjeeva Raj, Department of Zoology, Madras Christian College, Tambaram, Madras-59.	
11. Kerala University	16 April-28 May	Kerala, Minicoy, Laccadive & Amindive Islands	Professor O.M. Mathen, Department of Biology, Union Christian College, Alwaye-2.	
CHEMISTRY				
12. Utkal University	12 May-21 June	West Bengal and Orissa	Dr. K.S. Rao, Department of Chemistry, Regional College of Education, Bhubaneswar.	
13. Patna University	19 May-28 June	Bihar, Assam, Manipur, Nagaland and NEFA	Professor J.N. Chatterjee, Department of Chemistry, Patna university, Patna.	
14. Allahabad University	19 May 28 June	Eastern U.P.	Professor S.P. Tandon, Department of Chemistry, Allahabad University, Allahabad.	
15. Agra University	15 May-24 June	Western U.P. and Delhi	Professor S.N. Srivastava, Department of Chemistry, Agra College, Agra.	

Location and Duration of Summer Institutes—(Contd),

<i>Sl. No</i>	<i>University</i>	<i>Institute Dates</i>	<i>For Teachers From</i>	<i>Director & Location</i>
1	2	3	4	5
16.	Punjab University	2 June-12 July	Chandigarh, Punjab, Haryana, Himachal Pradesh and Jammu & Kashmir	Professor B R Puri, Department of Chemistry, Punjab University, Chandigarh.
17.	Jodhpur University	1 May-11 June	Rajasthan	Professor R C Kapoor, Department of Chemistry, Jodhpur University, Jodhpur.
18.	Gujarat University	1 May-11 June	Gujarat	Professor A M. Trivedi, Department of Chemistry, University School of Sciences, Gujarat University, Ahmedabad.
19.	Indore University	12 May-21 June	Madhya Pradesh	Professor A.P. Shitoot, Department of Chemistry, Holkar Science College, Indore
20.	Jabalpur University	12 May-21 June	Maharashtra and Jabalpur Division	Dr. S N Kaveeshwar, Principal, Government Science College, Jabalpur.
21.	Nagpur University	28 April-7 June	Vidarbha Region	Professor N V Kambekar, Department Chemistry, Vidarbha Mahavidyalaya, Amravati.
22.	Bangalore University	28 April-7 June	Mysore and Goa	Professor T.D Bhasker, Department of Chemistry, Central College, Bangalore
23.	Annamalai University	28 April -7 June	Madras and Andaman & Nicobar Islands	Dr K Ganapathy, Department of Chemistry, Annamalai University, Annamalaiagar.
24.	Andhra University	12 May-21 June	Andhra Pradesh	Professor M.N Sastri, Department of Chemistry, Andhra University, Waltair.
25	Kerala University	28 April-7 June	Kerala, Minicoy, Laccadive & Amindive Islands	Professor M.V. Verghese, Department of Chemistry, Sacred Heart College, Ernakulam.
<i>Special Institutes</i>				
26.	Rajasthan University	12 May-21 June	Science Methods (All India)	Professor A.N. Bose, Department of Chemistry, Regional College of Education, Ajmer.
27.	Mysore University	1 May-10 June	Training Colleges from Andhra, Mysore Kerala and Madras	Shri S R. Rao, Department of Chemistry, Regional College of Education, Mysore.

Location and Duration of Summer Institutes—(Contd.)

<i>Sl No.</i>	<i>University</i>	<i>Institute Date</i>	<i>For Teachers From</i>	<i>Director & Location</i>
1	2	3	4	5
28.	Osmania University	12 May-21 June	Special Institute (Using NCERT material for local teachers)	Professor V.R. Srinivasan, Department of Chemistry, University College of Science, Osmania University, Hyderabad.
29.	Madras University	5 May-14 June	—do—	Professor L.M. Yeddanapalli, Department of Chemistry, Loyola College, Madras-34
MATHEMATICS				
30.	Utkal University	12 May-21 June	Orissa, Assam, Manipur, Tripura, Nagaland, NEFA and West Bengal	Professor R. Misra, Department of Mathematics, Ravenshaw College, Cuttack.
31	Allahabad University	26 May- 5 July	Bihar nad Eastern U.P.	Professor Ram Kumar, Department of Mathematics, M.N.R. Engineering College, Allahabad.
32.	Kanpur University	15 May-24 June	Western U.P.	Professor S P Nigam, Department of Mathematics, D A V. College, Kanpur.
33.	Jammu & Kashmir University	23 June-3August	Punjab, Jammu & Kashmir and Himachal Pradesh	Professor M.R. Puri, Department of Mathematics, Jammu & Kashmir University, Jammu.
34	Sardar Patel University	5 May-14 June	Gujarat and Rajasthan	Dr. B.S. Yadav, Department of Mathematics, Sardar Patel University, Vallabh Vidyanagar.
35	Jiwaji University	17 May-28 June	Madhya Pradesh	Professor S.K.D. Gaur, Department of Mathematics, Government Science College, Gwalior.
36	Poona University	28 April-7 June	Maharashtra and Goa	Professor M.N. Bhat, Department of Mathematics, M.E.S. College, Poona.
37.	Poona University	28 April-7 June	Maharashtra Mathematics, J.S.M	Principal R.T. Kulkarni, Department of Mathematics, J.S.M. College, Alibagh.
38.	Bangalore University	30 April-9 June	Mysore	Professor J.F. Noronha, Department of Mathematics, Central College Bangalore.
39	Osmania University	12 May-21 June	Andhra Pradesh	Dr. Afzal Ahmad, Department of Mathematics, Osmania University, Hyderabad.

Location and Duration of Summer Institutes—(Contd)

<i>Sl No.</i>	<i>University</i>	<i>Institute Dates</i>	<i>For Teachers From</i>	<i>Director & Location</i>
1	2	3	4	5
40	Madras University	28 April-7 June	Madras and Andaman & Nicobar Islands	Dr Surya Prakash, Department of Mathematics, Madras Institute of Technology, Chrompet, Madras-44.
41.	Kerala University	16 April-28 May	Kerala, Minicoy and Laccadive & Amindive Islands	Professor S. Paramesvaran, Department of Mathematics, University College, Trivandrum
<i>Special Institutes</i>				
42	Delhi University	5 May-14 June	Sequential(All India)	Shri P.D Gupta, Principal, Ranjnas College, Delhi-7.
43.	Gujarat University	5 May-14 June	Training Colleges in Modern School Mathematics (All India)	Professor P.C. Vaidya Department of Mathematics, University School of Sciences, Gujarat University, Ahmedabad.
PHYSICS				
44.	Gauhati University	26 May-5 July	Assam, Manipur, Tripura, Nagaland & NEFA	Professor H Goswami, Department of Physics, Cotton College, Gauhati-1.
45.	Bhagalpur University	12 May-21 June	Bihar and West Bengal	Professor S P Sinha, T N B College, Bhagalpur
46	Kanpur University	26 May-5 July	Western U P., Delhi, Punjab, Chandigarh Haryana, Himachal Pradesh and Jammu & Kashmir	Professor B.S Bhargava, Department of Physics, V S S D Nawabganj, Kanpur
47.	Allahabad University	26 May- 5 July	Eastern U P.	Professor S.P Tewarson, Department of Physics, Ewing Christian College, Allahabad
48.	Jodhpur University	12 May-21 June	Rajasthan	Professor S. Lokanathan, Department of Physics, Jodhpur University, Jodhpur
49	Udaipur University	19 May-28 June	Rajasthan	Shri D.S Kothari, Department of Physics, M.B. College, Udaipur University, Udaipur
50.	Vikram University	5 May-15 June	Madhya Pradesh	Professor G S Shrikantia, Department of Physics, Regional College of Education, Bhopal-2

Location and Duration of Summer Institutes—(Contd.)

Sl. No.	Institute	Date	For Teachers From	Director & Location
1	2	3	4	5
51	Ravishankar University	12 May-21 June	Madhya Pradesh and Orissa	Dr. J.N. Das, Department of Physics, College of science, Raipur.
52.	Sardar Patel University	28 April-7 June	Gujarat	Professor A.R. Patel, Department of Physics, Sardar Patel University, Vallabh Vidyanagar.
53.	Poona University	1 May-10 June	Maharashtra	Professor S.G. Khandkekar, Principal, Premraj Sarda College, Ahmednagar.
54	Shivaji University	5 May-14 June	Maharashtra and Goa	Dr. V S. Patankar, Department of Physics, Shivaji University, Kolhapur.
55.	Mysore University	1 May-10 June	Mysore	Dr. V. Rajamadhava Rao, Department of Physics, Regional College of Education, Mysore-6.
56.	Osmania University	12 May-21 June	Andhra Pradesh	Dr. N. Rajeswara Rao, Department of Physics, University College of Science, Osmania University, Hyderabad.
57.	Madras University	21 April-31 May	Madras and Andaman & Nicobar Islands	Dr. G.A. Savari Raj, Department of Physics, St. Joseph's College, Trichinapally.
58.	Kerala University	16 April-26 May	Kerala, Minicoy, Laccadive & Amindive Islands	Professor T.B. Thomas Department of Physics, Union Christian College, Alwaye-2.

Science Notes

Laser Beam May Provide Communications Links

A big step towards communications systems which use light from lasers in the way that radio waves are used now has been announced in London.

It is possible to sweep across visible light frequencies from blue-green to infra-red, using an input at one frequency. There are possibilities, too, of extending the range into the ultra-violet.

Gaps Filled

Up to now, laser outputs have been restricted to separate frequencies. If a particular frequency were needed, the nearest one that a laser could produce had to be accepted. The new discovery fills the gaps in the spectrum, and frequencies can be selected at will.

In the SRDE system, the light output from a laser is passed through a cell filled with a special liquid. It undergoes a process called "beam trapping" which makes an enormous range of light frequencies available.

From these any one can be selected by means of a crystal of lithium niobate. This crystal will transmit a particular frequency according to its temperature—so by heating and cooling this the whole range of light frequencies can be scanned.

Because of their enormous band widths, laser beams of coherent light travelling along optical wave guides could carry thousands of telephone circuits, data transmissions, radio and television programmes, and so on. The discovery brings nearer the day when these potentialities might be exploited.

By Courtesy: British Information Service

Rescuing Waste Rain Water

Billions of cubic metres of rain water which usually go to waste may be harvested for agriculture and industry through runoff inducement methods developed by scientists of the Hebrew University of Jerusalem.

For the last three years, a team of University soil physicists, headed by Dr. Daniel Hillel, 37, of the University's Faculty of Agriculture in Rehovot, has conducted extensive research on runoff inducement in arid land in cooperation with scientists of the Volcani Institute of Agricultural Research. The Project, comprised laboratory as well as field trials.

Among the team's findings is that water harvesting according to their methods may eventually prove more economical than desalination and conveyance of sea-water, so often held to be the ultimate solution to the problem of water supply in arid regions.

As an example of what may be in store, Dr. Hillel said that Israel receives some 8 billion cubic metres of rain water annually, of which only 1.2 billion are harnessed and utilized in actual practice. Much more can be made available if grounds surfaces unsuitable for cultivation can be allocated for runoff inducement.

According to Dr. Hillel's definition, runoff is the amount of rain which does not enter the soil but trickles off the surface. In humid and semi-arid regions, runoff is generally undesirable as it entails loss of water in field and erosions. In arid zones, on the other hand, as well as wherever soil is non-arable (too stony, shallow, saline or steep), runoff inducement may be the only way to use the water.

Dr. Hillel explained that to serve as a dependable source of water, runoff must be induced artificially. The problem under investigation by his team had been to develop effective methods of treating the soil for runoff inducements and evaluate the performance.

Water Harvesting

By artificially sealing land surfaces, the Hebrew University scientists have caused the soil to reject the rain and collect the water off the slopes. The runoff inducement, which the researchers also call water harvesting, is done by means of mechanical treatments (stone clearing, smoothing and compaction), as well as by a variety of chemical treatments in order to crust, blind and water-proof the soil surface. Through these methods, which should be preceded by re-

moval of vegetation, it is possible to increase runoff several-fold.

Water obtained through runoff can be used either directly in agriculture to irrigate crops or indirectly for urban, industrial or engineering purposes, such as to fill ponds, cisterns or storage dams, or for groundwater recharge.

The main advantages of runoff, Dr. Hillel pointed out, includes: high quality water (not saline); availability in highlands (saves energy since conveyance of water to highlands involves great pumping costs) and availability inland far from the sea.

While runoff utilization is not new in this part of the world, it is only now being perfected in order to become a reliable source of water. Runoff farming was practised in the Negev in ancient times by the Israelites, Nabateans, Romans, and Byzantines. Archeological evidence of the widespread application of this agricultural method abounds in the Negev Highlands region, but even at best the ancients were not able to collect more than an average of 10 per cent of the annual rainfall, while the remaining 90 per cent soaked into the ground.

"Through scientific methods we are now able to get an 80-90 per cent yield of the rainfall with only 10-20 per cent going to waste," Dr. Hillel said, adding that circumstances now seem ripe in the setting-up of a pilot project for a large-scale and longterm economic trial to examine the experimental results under actual conditions of use.

Dr. Hillel has spent several years of his life in the Negev desert as a founder member of Kibbutz Sde Boker. He has also served as an agricultural research adviser to the Government of Burma, and a visiting Research Fellow at the University of California, Davis, and the United States Salinity Laboratory, Riverside. He is at present

Head of the Soil Science Department of the Hebrew University

By Courtesy: Consulate of Israel, Bombay

Nuclear-Powered Heart Pacemaker

Nuclear-powered pacemakers—small devices implanted into people with some forms of heart trouble—are being developed in Britain. They give the heart muscles an electrical boost to aid normal contraction.

Previously, pacemakers have been powered by tiny mercury batteries that last about three years. The power unit now being developed at the Atomic Energy Research Establishment at Harwell (Southern England) uses a radioisotope, plutonium 238, with this unit a life of more than 10 years is feasible.

Stainless Steel Cylinder

Heat from the radioactive decay of the isotope is converted into electricity by a miniature thermocouple which, together with the fuel, is implanted in the human body within a 5 X 1 cm stainless steel cylinder.

The cylinder prevents atomic particles radiated by plutonium 238 from damaging the body tissues. Only four-tenths of a gram of the plutonium fuel is used in the nuclear "battery".

Exhaustive tests have been made on the cylinders to safeguard against fracture. The tests included crushing under a load of two tons, and heating at 8500 Centigrade for several hours with an internal pressure of 10,000 lb per square inch.

Prototype

A prototype of the nuclear-powered pacemaker has been running since June last year, generating 72 pulses a minute and driving a commercially designed pacemaker circuit.

Trials on animals are expected to begin this year, and clinical trials with heart patients will follow.

By Courtesy: British Information Services.

Skin Grafts Taken from Cancer Patients save Lives

It may seem strange that a cancer-afflicted patient can help another patient to survive, but Israeli scientists have discovered that this is so in the case of skin grafts. Such grafts, taken from donors suffering from malignant tumors, endure for a significantly longer time before rejection than skin grafts from non-tumorous patients. This may help the recipient patient to overcome the critical period before his own skin grows, according to research work done by Dr. Nahum Ben-Hur, of the Hadassah-Hebrew University Medical Centre, and his colleagues.

This discovery may have considerable clinical implications. In cases of severe burns or other injuries skin grafts are used as 'biological dressings', to prevent infection and to stop leakage of proteins, electrolytes and other vital substances. Unfortunately, the early rejection of the skin graft may make it impossible for the patient to retain the biological dressing and he dies. If the life of the graft can be significantly prolonged, the patient can be saved. Skin grafts taken from patients with malignant disease have the necessary prolonged survival time before rejection.

70 per cent burns

This was proved at Hadassah, when Dr. Ben-Hur and his team treated a young patient with second and third degree burns involving 70 per cent of the body surface, by grafting skin from several donor patients. One of these had died from cancer of the larynx, while the others had died from non-malignant diseases. The graft from the can-

cer patient survived for 60 days while those from the other donors survived only 12-19 days. The prolonged survival time of the skin from the cancer patient enabled the burnt patient to overcome the critical period and after 128 days he left the hospital.

The problem in transplanting organs or skin from one person to another is rejection by the recipient, as is well known from the cases of heart transplant rejection reported lately.

The reasons for rejection of a transplant is that nature has provided the bodies of living creatures with a wonderful system of immunity. When a foreign protein, such as a bacteria or virus, enters the body, antibodies are formed which rush to attack it. The same process goes on with a transplant which is regarded by the body as an invader. Each foreign protein has a certain characteristic pattern of transplantation antigens, which stimulate the formation of specific antibodies capable of destroying. The usual accepted method of combating this immunological response of rejection to grafting is to try to depress the number of antibodies being produced by the body to fight the foreign protein. This is done by administering cortisone, cyto-toxic cell agents, anti-white blood cell serum, or by means of radiation.

Grafts survive

In previous work at Hadassah, Professor Zvi Neuman, Professor Abraham Hochman, Drs. E. Robinson, N. Ben-Hur, S. Biran and J. Shulman found that in 40 patients, who were subjected to two skin transplants, one from a normal donor and one from a patient with cancer the survival of the grafts from the cancer patients was significantly prolonged.

In experiments with mice suffering from tumors, Dr. Ben-Hur and his team found that skin grafts taken from these mice and

grafted on to normal mice survived significantly longer periods than grafts taken from normal mice. When healthy mice were injected with tumor and then a week later skin was taken from them for grafting, the results were remarkable: the survival time of the grafts was three times longer than that of grafts taken from mice without tumor injections. This suggested the idea that there is a release of some factor from the tumor cells which is responsible for the prolonged survival time of the grafts. This factor has been designated as the "antigen loss factor", and further research is being carried out to find the active principle involved in the prolongation of the life of the graft.

For his work, both clinical and experimental, on transplantation biology, Dr. Ben-Hur has been awarded the 1968 Prize of the Education Foundation of the American Society of Plastic and Reconstruction Surgery. He reported on his work at the recent international congress of surgeons in Jerusalem.

By Courtesy: Consulate of Israel, Bombay

Spy Out Quasars

ARTHUR BOURNE

Editor SPECTRUM

QUEEN Elizabeth inaugurated Britain's new £1,000,000 Isaac Newton telescope at the Royal Greenwich Observatory at Herstmonceux, Southern England.

The 90-inch telescope has been designed and built by the firm of Grubb Parsons, the famous optical and scientific instrument manufacturers based at Newcastle-upon-Tyne in North-East England.

The Isaac Newton telescope is the largest in Western Europe and the fifth largest in the world. Its huge mirror can collect light from the remotest parts of the universe.

Its main use will be in studies of remote galaxies and in particular the search for, and the study of, quasars-stars that give out more light than an entire galaxy and which may provide keys to the origin of the universe.

Isaac Newton, the English mathematician and astronomer, invented and built the first reflecting telescope in 1668. His telescope would stand on a table. But the Herstmonceux instrument is housed in a 90-foot-high dome which can be seen for miles around.

The telescope itself stands on a platform 48 feet high to raise it above the surrounding round mists. The design embodies unique engineering achievements, such as the compressed air bag which supports the 98-inch mirror and the 22-foot-diameter high-pressure oil bearing which supports the 100 tons of moving parts.

The dome, which weighs 120 tons, can be rotated completely in four minutes.

The instrument is expected to have a useful life of at least 50 years and will enable British astronomers to play a leading part in observational astronomy, looking for objects which up to now have only been discovered by radio astronomers.



Annual Conference of the All India Science Teachers Association

THE 13th Annual Conference of the All India Science Teacher's Association was held at Ambala under the chairmanship of Dr. A.C. Joshi, Vice-Chancellor, Banaras Hindu University during December 25-29, 1968. The Conference was inaugurated by the Governor of Haryana in the morning of December 26. Shri Chakravarty emphasised the need for developing science education in India in both quantity and quality. Dr. S.K. Mitra, the Joint Director of the National Council of Educational Research & Training opened the exhibition of scientific instruments, equipment and books. Three symposia were held on the following topics.

1. Science Textbooks are a hindrance to the teaching and learning of science.
2. Evaluation in science and mathematics.
3. Programmed learning in science and mathematics.

All the three symposia attracted much attention and a large number of delegates participated.

Dr. R.C. Paul, Professor of Chemistry, Punjab University, Chandigarh, delivered the Krishnan Memorial Lecture in which he related how inorganic matter changed to organic on the earth.

Guest lectures were delivered by Dr. U.K. Bose of Meteorological Department, New Delhi on "Basic concepts in Meteorology", by Mr. R. Jayaraman, Scientist, CSIR, on "The main issues in Oceanography"; by Shri O.P. Kahol, Principal, GMN College, Ambala Cantt. on "Scientific and Social Implications of Space Travel" and by Prof. B.S. Tewari, Department of Geology, Punjab University Chandigarh on "Geology in the Service of Man".



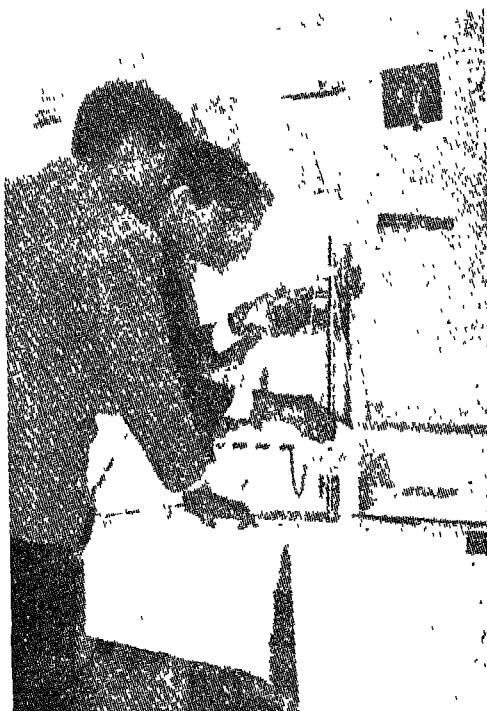
Shri Chakravarti, Governor of Haryana viewing the Exhibits of the Department of Science Education

Some foreign delegates also took prominent part in the activities of the conference. Dr A. Balezin, Chief of the Unesco Team in New Delhi spoke on evaluation in science and mathematics; Dr. Irwin L. Slesnik, Science Advisor, USAID, spoke on responsibilities of science teaching community to population problem, and Prof. H. Meiners, of the National Science Foundation, New Delhi spoke on Harvard Project Physics. Subject sessions in Physics, Chemistry, Biology and Mathematics were held in the afternoon of December 27 in which the delegates were exposed to the materials prepared by the NCERT Study Groups and those prepared under the NCERT / Unesco Project

The Valedictory Function was presided over by the President in which Dr. P V. Kahr,



Improvised Apparatus in Chemistry Teaching



Improvised Equipment for Teaching of Physics

Deputy Director, Unesco Centre for Science and Technology in South Asia delivered the Valedictory Address and Shri D.I Lal, DPI, Haryana gave away the prizes to the award winners in the teachers and students Science Activities competition



Equipment for Study of Mathematics



Equipment to show Muscle contraction in a Frog used in the Teaching of Biology

The Association passed a few resolutions regarding the improvement of science and mathematics education in the country.

Seminar of the Representatives of State Institutes of Science Education

THE seminar of the representatives of State Institutes of Science Education was held from March 7 to 14, 1969. The main purpose of this seminar was to familiarise the details of the NCERT/Unesco Project

for the Improvement of Science Teaching to all the representatives of the State Institutes. The Department of Science Education has already prepared all the curriculum materials Textbooks and teachers guides for the three years of the middle school stage and these books are being tried in 30 experimental schools in Delhi. The Delhi administration has introduced the material in class VI in all the schools beginning from June 1968. Other States who have shown interest in these are—Andhra Pradesh and Mysore. In order to make these materials familiar to all, representatives of different State Institutes of Science Education and State Institutes of Education were called for a seminar. The seminar was inaugurated by Dr. S.K. Mitra, J.D. of the NCERT on March 7. Then there was a general discussion of the programme following an address by Dr. M.C. Pant. One day was spent in listening to the reports of the activities of the different State Institutes of Science Education with regard to improvement of science teaching in their respective states.

As part of the second stage the Department of Science Education has developed syllabi for the three classes of the high school. The philosophy, scope and depth of these materials were discussed by different subject experts of the department. On the third day the participants discussed primary school science programme and the Handbooks for primary teachers developed by the Department of Science Education. In the afternoon, there was a discussion on the preservice and inservice programmes proposed by the Department. The next two days there was a discussion of the middle school science programme and the materials prepared under the project. The materials prepared by the different Study Groups of the NCERT were also discussed.

They were shown the equipment and kits

developed for physics teaching and for chemistry teaching. They were also shown several experiments featured in the teaching materials in biology. On the last day the delegates discussed the action programme in which their institutes could collaborate with the Department of Science Education. The participants also visited the National Council of Science Education one afternoon.

On the whole the discussions were very fruitful and it is hoped that many of these States would either adopt or adapt the materials prepared by the D S E in science and mathematics.

International Conferences

The Department received invitations to participate in the following international seminars and conferences and contributed its experience in the development of programmes of Science Teaching.

1. Evaluation in Chemistry Teaching organized by the International Unit of Pure and

Applied Chemistry in collaboration with the UNESCO at the University of Paradeniya, Kandy, Ceylon.

2. Regional Workshop for UNESCO/UNICEF assisted projects in science education in Asia held at Bangkok (November 1968).

3. Planning meeting for UNESCO's programme in integrated science teaching organized by UNESCO at Paris (March 1969).

Dr M C. Pant, Head of the Department of Science Education represented India at all these seminars and conferences.



*Dr. M C. Pant in the Regional Workshop
—UNESCO/UNICEF assisted projects in
Science Education*



R.C. SHARMA

SS.56: (a) There are 9 points on a line l in the order $P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9$ and P is a variable point on the line. For what position of P is the sum of the lengths of $PP_1, PP_2, PP_3, PP_4, PP_5, PP_6, PP_7, PP_8$ and PP_9 is least. Give reasons for your answer

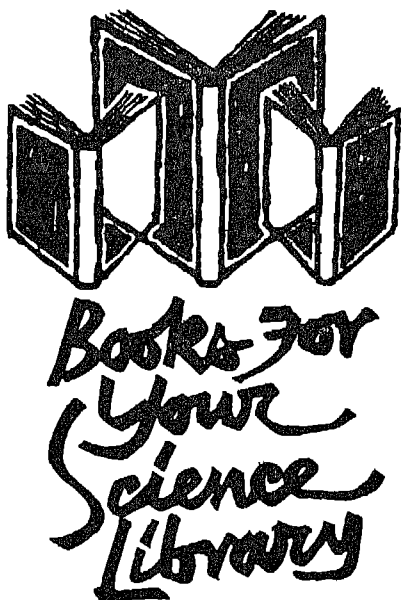
(b) If in 1 (a) there had been 8 points on the line, what would have been the answer and why?

SS.57: Prove that the sum $1^k + 2^k + 3^k + \dots + n^k$ where n is an arbitrary integer and k is odd, is divisible by $1 + 2 + 3 + \dots + n$.

SS.58: 200 students are positioned in 10 rows, each containing 20 students. From each of the 20 columns thus formed the shortest student is selected and the tallest of these 20 students is named A. These students now return to their initial places. Next the tallest student in each row is selected and from these 10 tall students shortest is named B. Who is taller A or B, if they are different students?

SS.59: All the integers beginning with 1 are written successively i.e. 123456789101112131415... What will be the digit at 101 788th position?

SS.60: Out of seven men each owned a different number of rupees. The ratio of any one's fortune to the fortune of every man poorer than himself was an integer. In total, the combined amount of money was Rs. 2879. How many rupees did each have?



Teaching Children Science: an Inquiry Approach Louis I. Kushlan and A. Harris Stone
Wadsworth Publishing Co., 1968

WITH the tremendous growth of scientific knowledge the methods of teaching science have also changed. Formerly science teaching was mainly book-centred and most experiments were of the verification type. Even here the pupil activity was almost nothing and a few demonstration experiments were conducted by the teacher. The modern trend in science teaching emphasises the importance of learning from experiences of the pupils. The pupils are given activities which are investigative in nature. This method is called the "inquiry" or "discovery approach".

There are very few books which deal in detail on this method of teaching science.

"Teaching Children Science: an Inquiry Approach" is a very recent book and presents all aspects of this method.

We have rightly come to a stage when we consider that the common citizen should acquire scientific literacy and that he should develop a scientific attitude. For reaching this goal our teachers of science must be properly trained in the current methods. The science teaching is not a mere teaching of facts of science. The author of the book presents this modern science teaching process in the chapters.

The first chapter defines science and goes on to describe the "tactics and strategy of science". The second chapter deals with the educational psychology of the child which affects the teaching of science and learning at that stage. The third chapter is historical and traces the evolution of elementary school science teaching over one hundred years. In the next two chapters, the authors present the philosophy, principle and the meaning of the inquiry method. Teaching of facts of science is not very important but how the scientists arrived at these facts. The sixth chapter describes a few curricula of elementary science.

The next four chapters describe different kinds of tools of learning and teaching by the inquiry method. These include experiments, excursions, films, books and facts of evaluation.

The last two chapters provide the teacher with practical experience in adopting an enquiry approach. These experiences introduce the teacher to scientific investigation so that they may understand the principle investigated and the problems. The last chapter stresses the importance of planning.

At the end of each chapter references for further study are given which may be useful to the teachers and their guides. There are also questions to stimulate thinking.

The book would be very useful to teacher educators for pre-service as well as inservice courses. It would be a useful addition to the libraries of teacher training colleges and teacher training institutes. This "Inquiry approach" should gain currency among all science textbook writers and curriculum framers in our country.

S. DORAISWAMI

Methods for Science Masters

C B. Owen

ELBS, & Macmillan Co London-1964

THIS book is directed to the prospective young science teachers to introduce them to understanding of the main purpose of teaching science and how to do it successfully.

The author develops well in a simple direct manner as to what is meant by "science" and how we arrive at laws from observation and experiment. He discusses that though science teaching has several aims, both from the points of view of needs of the society and the child, the methods of science and attitudes are most important. The process of science has been well illustrated in the chapters on "How Scientists work", "What does it mean" and "What is the answer". The limitations of science and its place in religion is not lost sight of in the following discussions.

The prospective teachers are given practical suggestions and tips on planning and starting a laboratory and on the essential laboratory and workshop skills needed by a teacher. The prevention of accidents and first aid in case of accidents has received due

attention. There are again some useful suggestions on lesson planning, use of note books and their correction and guidance on evaluating knowledge of science of pupils. The author has stressed the need for proper guidance by teachers for preparing boys for examinations.

The list of apparatus, chemicals and certain formulas are useful for any general science teacher and so is the bibliography for further reading. There are also practical guidance for field experiences, excursions and organization of science shows and museum activities, which are essential ingredients of good science teaching at any level.

On the whole though the book may not be used as a textbook for a professional course of training, it is eminently suitable as a guide for the new class-room teacher providing him with pragmatic, simple and matter of fact instructions as to how to do his day to day work successfully. The strength of the book from the Indian point of view is its extreme simplicity and directness of the language which makes it comprehensible to all teachers of the elementary level. In the present state of explosion of knowledge in the facts of science, the need of the day is to make science teachers appreciate the importance of the "process" of science rather than the "products" of science. This attitude is maintained throughout the book. It is devoid of the usual pedagogic and psychological terminology which may make a book learn but not read and acted upon.

It is felt that all prospective science teachers would benefit from this book and thus should find a place in the libraries of training colleges and schools.

N.K. SANYAL

SCHOOL SCIENCE

Vol. 7

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In This Issue

MAGIC BENZENE

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INDIA'S CONTRIBUTION TO ASTRONOMY—
RELIGIOUS AND HISTORICAL
BACKGROUND

•

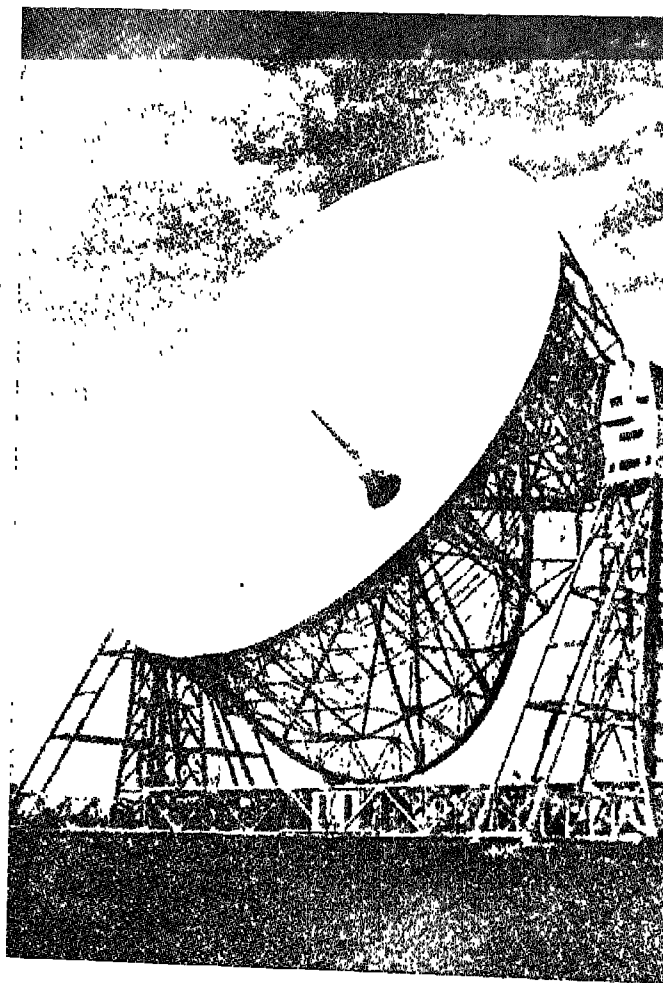
POSITION OF GENERAL SCIENCE
IN INDIAN SCHOOLS

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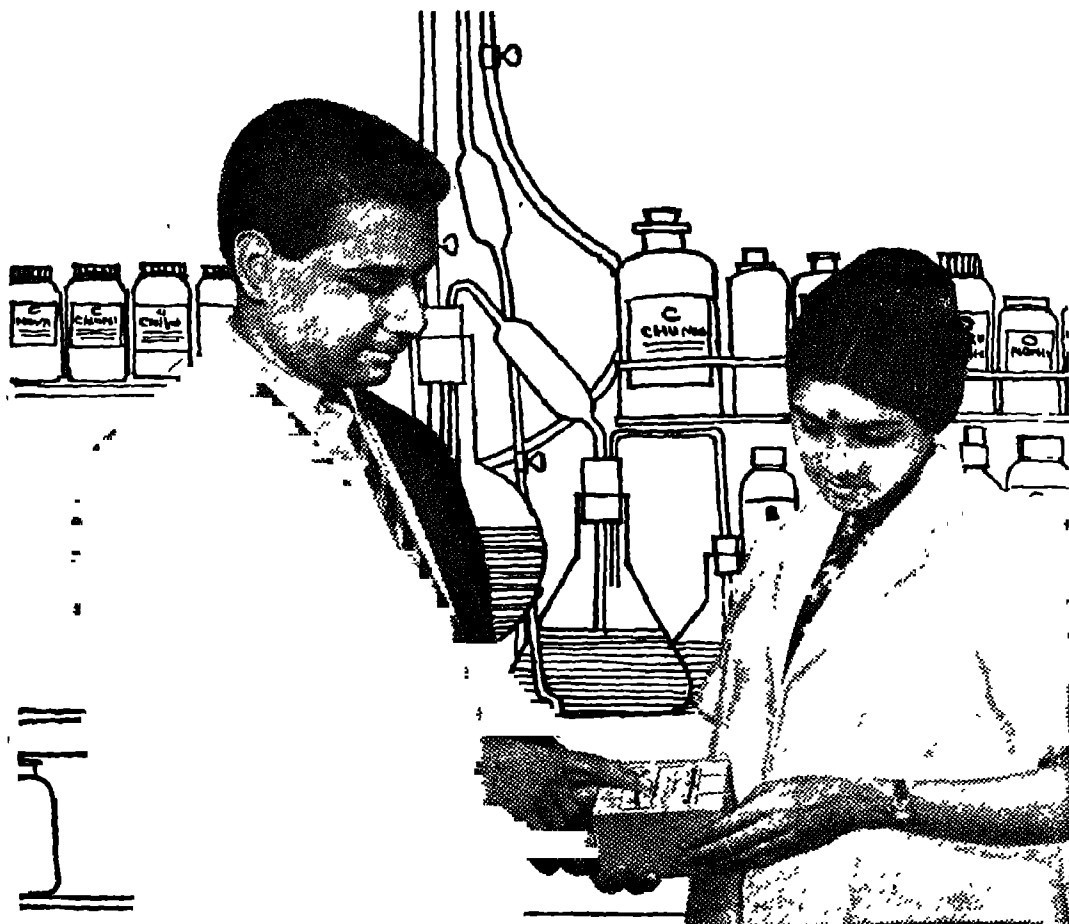
THE GARDENS AND PARKS OF DELHI

•

STUDY OF SURFACES-I
SURFACE TENSION



A View of Jodrell Bank



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CONTENTS

	Magic Benzene	<i>Y.I. Naumov And N.K. Sanjal</i>	99
	India's Contribution to Astronomy--- Religious and Historical Background	<i>S.C. Chatterjee</i>	105
	Position of General Science in Indian Schools	<i>Ashok Sinha And Bina Ghosh</i>	110
	The Gardens and Parks of Delhi	<i>G.S. Paliwal</i>	120
	Study of Surfaces I, Surface Tension	<i>L.D. Ahuja</i>	123
<i>Chief Editor</i> M.C. PANI	<i>Classroom Experiments</i>		
	A New Approach to the Anatomy of a Leaf	<i>Syed Jalaluddin</i>	126
	<i>Science Abroad</i>		
	Air to the Rescue	<i>James Lawrie</i>	128
	Crystals: Magic World		129
<i>Associate Editor</i> S. DORAISWAMI	<i>Young Folks corner</i>		
	The Life and Work of Charles Darwin	<i>Deepak Yadav</i>	132
	Great Dutch Pioneer of Scientific Research	<i>Willem Hendrik Keesom</i>	135
	<i>New Trends in Science Education</i>		
	The NCERT Project on School Chemistry	<i>N.V. Subba Rao</i>	137
	<i>Science Notes</i>		141
	<i>News and Notes</i>		149
	National Science Talent Search Examination Result of 1969		154
	Problems in Mathematics	<i>R.C. Sharma and V.I. Baulin</i>	167
	<i>Books for your Science Library</i>		168

EDITORIAL

Among the highlights of this issue of *School Science*, the pride of place goes to *Magic Benzene* by Y.I. Naumov and N K. Sanyal. The structure of benzene, which for many decades has been the subject of endless dispute among theoretical chemists, is yielding new surprises even in our day. In this article the authors narrate the fascinating story of the discovery of benzene and of the various attempts to arrive at the structure of this compound and its derivatives. But perhaps the most interesting part of this article is a discussion of the very latest models of the structure that have been proposed.

Turning from chemistry to physics, L D. Ahuja's *Study of Surfaces—I: Surface Tension* will be of particular usefulness to students. The author has started a series beginning with the present article on surface tension, and readers will perhaps share our appreciation of the clarity with which the subject has been treated.

Readers will recollect that in our previous issue we carried Prof. S. Chandrasekhar's lecture on Astronomy in Science and Human Culture. The thread has been taken up in this issue with S.C. Chatterjee's *India's Contribution to Astronomy: Religious and Historical Background*. The title is self-explanatory and the article needs no further comment except that it lives up to its title.

Of particular interest for teachers and educators is *Position of General Science in Indian Schools*, by Ashok Sinha and Bina Ghosh. The authors have made a detailed analysis of the school syllabi for general science used in the various States of India, and have suggested how existing shortcomings in the teaching of this subject may be remedied.

For those interested in botany, there are two articles. In *The Gardens and Parks of Delhi* G.S. Paliwal describes the plants found in the avenues and public gardens of Delhi, while Syed Jalaluddin in *A New Approach to the Anatomy of a Leaf* under the feature "Classroom Experiments" describes a new method—"the injection method"—for the study of leaf anatomy.

The other regular features like "Science Abroad" and "Young Folks Corner" contain, as usual, notes on a variety of scientific subjects of interest both to students and teachers.

Magic Benzene

Y.I. NAUMOV AND N.K. SANYAL

Department of Science Education, NCERT,
New Delhi

AMONG the numerous organic compounds there are only a few which have so stormy a history as benzene. For many decades the structure of benzene was the subject of endless disputes among theoretical chemists. Many hypotheses of classical chemistry have been rejected after studying both the properties and the suggested structure of benzene. It is interesting that, even in our days, when science has unravelled many secrets of matter, the structure of benzene and its derivatives are yielding new surprises for research workers.

Benzene was discovered by Michael Faraday in 1825. It is a colourless liquid with a characteristic smell. It boils at 80°C (STP).

The story of the discovery of benzene is rather interesting. After the introduction of gas lighting in London during 1812–15 the illuminating gas, prepared from the fat of whales, used to be delivered to the city in iron containers. The containers were usually kept in the basements and from there the gas was piped throughout the house. But an extremely unpleasant fact was soon noticed. In very cold weather the gas seemed

incapable of burning with a bright flame. In 1825 the owners of the gas works consulted Faraday on the subject. He found that in these cases the gas constituents capable of burning with a bright flame condensed at the bottom of the container as a transparent liquid layer. While investigating this liquid, Faraday discovered a new hydrocarbon—benzene.

In 1834, Mitscherlich isolated the substance while distilling benzoic acid. He worked out its composition which was C_6H_6 and identified it as the substance discovered earlier by Faraday.

Soon after this discovery benzene ceased to be only a laboratory reagent. It was found that benzene could be easily extracted from coal tar. The new substance was found to be very active chemically.

A derivative from benzene, nitrobenzene— $\text{C}_6\text{H}_5\text{NO}_2$ —was prepared from benzene. In 1842, the Russian chemist Zimin reduced nitrobenzene to aniline— $\text{C}_6\text{H}_5\text{NH}_2$. Aniline has become the forefather of a large family of aniline synthetic dyes. Benzene is used in the manufacture of the following* (the order indicating approximately its quantitative use):

Styrene, phenol, synthetic detergents, cyclohexane for nylon, aniline, DDT, maleic anhydride, dichlorobenzene, benzene hexachloride, nitrobenzene, diphenyl insecticides, fumigants and solvents. Benzene has also other miscellaneous synthetic uses.

The first period of development of organic chemistry showed a great accumulation of experimental facts. There was no chemical theory to explain them. The absence of a common theory of structure of organic compounds hindered further progress in organic chemistry. In 1869, A.M. Butlerov, the

* *The Condensed Chemical Dictionary*, Seventh Edition, Reinhold Publishing Corporation, New York, 1966, p 106.

Russian chemist developed the theory of the chemical structure of the organic compounds.

This theory generalizes the inter-relationship between properties of organic substances and their molecular structure. It explains such important concepts like isomerism, high chemical activity of unsaturated hydrocarbons, mutual influence of atoms in a molecule, etc. The validity of this theory has been proved by enormous experimental data. However, benzene and its derivatives could not be put within the framework of that theory.

It was assumed that the benzene molecule has a linear structure. One of the possible formula of the composition C_6H_6 , may be represented as follows:

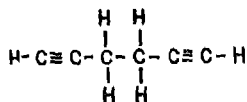


Fig. 1. Suggested linear formula of benzene (This is really Dipropargyl, an isomer of benzene.)

Such a compound should form additive compounds with halogens readily, and also form salts with copper or silver just like acetylene. Besides, the properties of the extreme end H-atoms should differ from those of the other H-atoms. Benzene reacts with halogens, but this is a case of the reaction of substitution. Experimental evidence shows that all H-atoms of the benzene molecule are equivalent.

In 1865, H.F. Kekule, a German chemist, presumed a cyclic structure of benzene, as shown in Fig. 2 below.

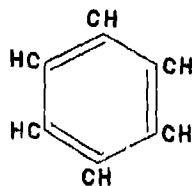


Fig. 2. Structural formula (after Kekule)

The main objection to the formula suggested by Kekule was directed towards the number of possible ortho-substituted products. If the double bonds are in fixed position, two ortho-substituted products should exist. (Fig. 3), while experimental evidence points to only one such product.

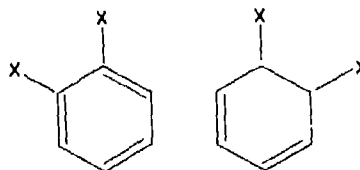


Fig. 3. Possible ortho-substituted products of benzene

Later in 1890 Kekule suggested another hypothesis to explain the existence of only one ortho-isomer. He assumed that the double bonds of the ring were in a state of constant oscillation. In other words each C—C pair was alternately to have a single bond and a double bond between them, as shown in Fig. 4 below.

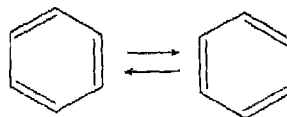


Fig. 4. The oscillation states in the molecule of benzene (after Kekule)

In 1867, the English Scientist D. Dewar suggested his formula of benzene structure (Fig. 5). Dewar's formula predicted the existence of two mono-substituted derivatives of benzene (Fig. 6). Again, it has not been supported by experimental evidence.

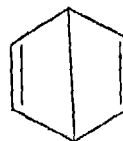


Fig. 5. Benzene structure (after Dewar)

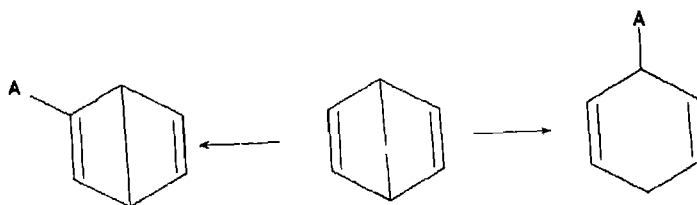


Fig. 6. Expected mono-substituted derivatives of benzene (after Dewar)

According to the German chemist A. Ladenburg, the Benzene molecule has the shape of a trihedral prism (Fig. 7)

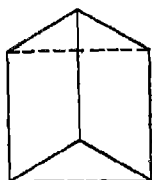


Fig. 7. Benzene structure (after A. Ladenburg)

In this case the four di-substituted derivatives of benzene are expected to exist (Fig. 8), whereas only three relevant derivatives of benzene are known (e.g. ortho, meta and para—dibromobenzene).

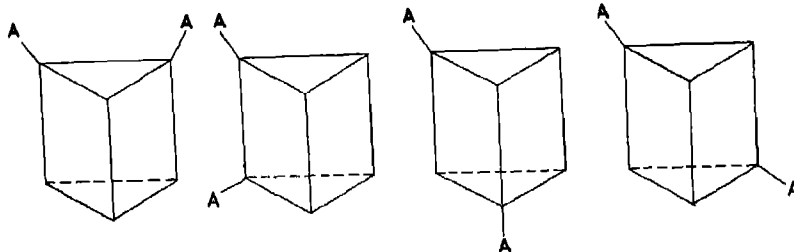


Fig. 8. Expected di-substituted derivatives of benzene (after Ladenburg).

At the end of the nineteenth century, J. Thiele, a countryman of Kekule suggested that in the case of benzene, the valency may be characterized not by whole numbers but by fractional ones also. Thiele linked C—atoms of benzene by one and a half bonds and expressed additional halved bonds between the C—atoms as closed dotted lines, as in Fig. 9 below.

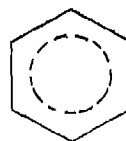


Fig. 9. Structural formula of benzene (after J. Thiele)

Surprisingly, it was found much later that the Thiele structure looked very much like the real structure of benzene. So Thiele came to the real structure of benzene intuitively but he could not prove his brilliant hypothesis due to the absence of experimental data at that time.

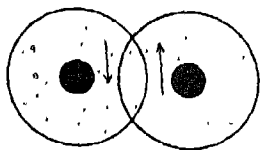
The close cooperation between physics and chemistry has been very fruitful in determining the structure of benzene. It has been found by X-ray analysis that the benzene molecule was a plane hexagon. This discards the space model of Ladenburg (Fig. 7). Spectral analysis shows that the properties

of all the six H—atoms of benzene molecule are equivalent. This conclusion rejects the asymmetrical model for benzene suggested by Dewar (Fig. 5). Physical methods show that the distances between the C—atoms in benzene molecule are equivalent and equal to 1.40 Angstrom units ($1 \text{ \AA} = 10^{-8} \text{ cm}$). From the Table 1 it follows that the C—C distance in benzene is something like the average of the C—C distances of single and double bonds.

TABLE 1

Compound	Length of C—C bond (\AA)
Ethane (Single bond)	1.54
Benzene	1.40
Ethylene (Double bond)	1.34

It is therefore clear that the nature of C—C bond in the benzene molecule needs special consideration. A covalent bond is typical for the majority of organic compounds and some diatomic molecules like H_2 , Cl_2 , etc. Here the single bond (δ -bond) is formed by the overlapping of both the electrical and magnetic fields of so-called S -electrons. The clouds of S -electrons have a spherical shape with an infinite radius. The centres of such clouds coincide with the nuclei of atoms. The fact of overlapping of electronic clouds is essential, but not sufficient to form a bond. Each electron has its own moment of rotation (spin). According to the laws of quantum mechanics link between atoms may be formed if spins of their electrons are directed in opposite ways (Fig. 10).

Fig. 10. The formation of δ -bond in hydrogen molecule

In the case of multiple bonds (e.g. in ethylene molecule) only one of them is δ -bond. The second bond (π -bond), formed by a pair of p -electrons with contrary spins. Their clouds appear to form symmetric spatial figures of 'eight', which are perpendicular to the molecule's plane (Fig. 11)

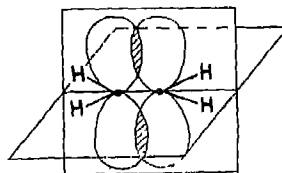
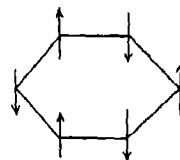


Fig. 11. Electronic structure of ethylene molecule

It has been found also that a π -bond was less strong than a δ -bond.*

Each pair of C—atoms in benzene molecule is linked by one δ -bond and one π -bond. The axes of clouds of p -electrons are perpendicular to the molecule's plane formed by δ -bonds (Fig. 12).

Fig. 12. The scheme of π -bonds in benzene molecule (antiparallel spins are shown as opposite arrows)

Yet π -bonds in benzene molecule are not equivalent to those of ethylene molecule. The p -electrons have a high mobility that cannot be manifested in a short ethylene molecule. The high mobility of p -electrons was found in the molecules with conjugated bonds (divinyl, for instance). In the case of divinyl, only one electronic cloud was formed. In the divinyl molecule electrons do not

* The strength of a chemical bond is characterized by so-called energy of breaking a bond.

belong to any particular atom at a given moment (delocalization of electrons). It may be represented by the Fig. 13.

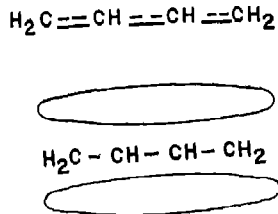


Fig. 13 Delocalization of electrons

In the molecule of benzene *p*-electrons are delocalized even more than those in divinyl molecule. They move along the ring freely. This may be represented by the following schemes (Fig. 14)



Fig. 14 The delocalization of electrons in benzene molecule.

This was the state of knowledge about this famous compound benzene, till five years ago. But five years is rather a long term for science.

The reaction of polymerization of acetylene benzene (Fig. 15) was suggested by Berthelot

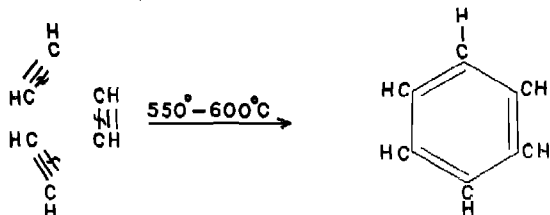


Fig. 15. The synthesis of benzene from acetylene

in 1866. The yield of benzene was small, but the synthesis might illustrate the following points:

(a) the existence of double bonds in

benzene molecule.

(b) the inter-relationship between unsaturated and aromatic hydrocarbons.

In 1964, a group of Belgian scientists (H.G. Viche, R. Mermyl, J.E.M.M. Oth, J.R. Sindors and P. Valange)* studied the products of polymerization of *tert*-butylfluoro-acetylene. It might be expected that the substituted acetylene would react like acetylene as follows (Fig. 16).

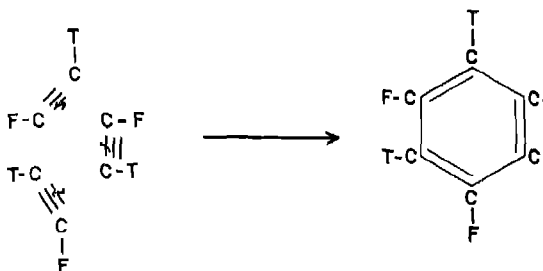


Fig. 16. The expected scheme of trimerization of *tert*-butylfluoroacetylene

The Belgian chemists were lucky to isolate three new structural isomers of the derivatives of benzene (Fig. 17) at the same time, instead of the anticipated one compound.

The first isomer is a crystalline substance. (M.P. 187° C). It appears to have the prismatic structure suggested by Ladenburg. Because of that it has been named as *prisman* (Fig. 17(a)).

The second isomer is a liquid (B.P. 140° C at 11 mm. Hg). Its structure did not resemble any one of the previously suggested structures. It was named as *benvalene* (Fig. 17(b)). On heating to 220° C this isomer is converted into the anticipated benzene derivative shown in fig. 16.

The third isomer has the structure resembling Dewar's model (Fig. 17(c)). This isomer is unstable and transforms quickly into the anticipated isomer shown in Fig. 16.

* ANGEW Chem 76(22) 922 (1964); C.A. 62, 1583f.

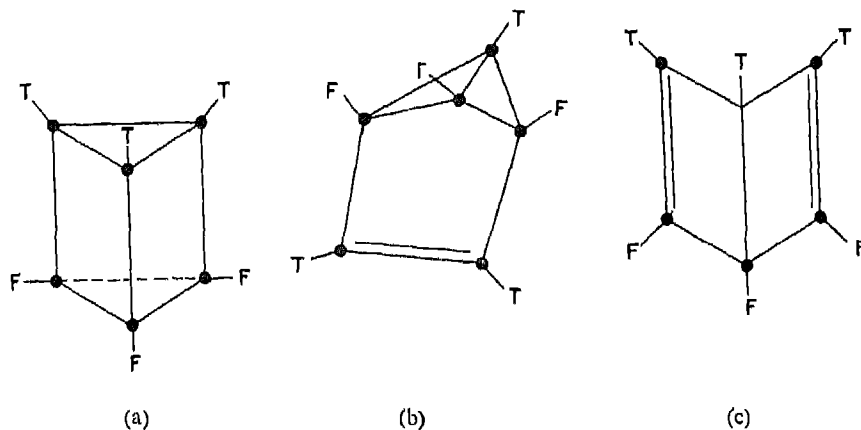


Fig. 17. New structural isomers of benzene derivative $[T = -C(CH_3)_3]$

It is interesting, that the two models of benzene which seemed to have been of historical interest only, recently acquired some real meaning after nearly a century.

It is difficult to predict what the discovery of the new structural isomers of benzene will give to science, yet it is clear that a new page has been opened in the biography of benzene

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India's Contribution to Astronomy— Religious and Historical Background

S C. CHATTERJEE

Kalimpong, W. Bengal

IN the dawn of civilization people must have had a rudimentary knowledge of time and space, and all the ancient scriptures regarded the universe as consisting of a flat circular earth below and a heaven above through which the sun, the moon, and the stars move. Between them was the middle air, the abode of clouds and demigods. This cosmological picture was considerably changed by later religious thought, but the heavenly bodies were still worshipped as gods. In India the *Rig Veda* mentions that observatories were erected for astronomical purposes, as the practice of sacrificial rituals demanded the setting up of altars for religious performances, and therefore some astronomical knowledge was necessary for determining the propitious times and dates for periodic sacrifice. Thus some astronomical knowledge became necessary. Like the Babylonians and the Greeks, the Indian priests also kept detailed records of the rising and the setting of various celestial bodies, and thus established

a kind of calendar; but without a clear idea of cause and effect. It was but natural that Divine Will was recognised, and the heavenly bodies were regarded as gods. A general belief in astrology was the natural consequence.

During the Upanishadic, the Brahmana, and the Aranyakya periods even those philosophers like Kanada, Gautama and Charvaka whose motives were scientific rather than religious were hardly in a position to drive their speculations home to the point of proof against their scriptures. They tried to get their ideas stated in a consistent and plausible form and had to see how far the results tallied with the experiments of common experience. Considerable progress was made in their observations of the heavens and the inexorable mathematical laws and rational science gave greater prominence to astronomy than astrology. Heaven was, however, still regarded by most people as a place where gods had their abode; and without a systematic layout of planets and stars there could not be any great progress in astronomy, and the original rational impulse behind enquiries into Nature began to evaporate and disappear. If the planetary system had been properly worked out, and scientific reasoning and the worship of natural laws given preference against the semi-human divinities of the sky, the universe would have been regarded as a vast organism cemented into a coherent unity by sympathetic forces, with Nature as the guiding principle, and the celestial bodies as its purest expression. Instead, the astral religion, specially of Greece and Babylonia, kept its hold; and a proud and long tradition of astrology was maintained intact. Astronomy was made more subservient to it than to physics.

As time rolled on, the system of astrology in India reached its scientific maturity and began to be regarded as a social science, and

astronomy a natural one. It has been argued that since astrology deals with material things, it is bound to be imperfect owing to human frailty; but astronomy gives clear-cut results and hence is reliable.

Foreign Contribution

In the domain of astronomy the Egyptians claim to be the first people who divided days and nights into twelve hours and invented water-clocks which they used specially in the night for knowing the time. They used sun-clocks during the day, but in astronomical observations they hardly made any progress. The Babylonians, however, went much further. They invented an improved form of clock known as the water-clock by collecting water from one sunrise to another and by dividing the water into equal parts. It is not clear why a day and night of twelve hours each and not of eight or ten hours were taken. Apparently a compromise was made and the sexagesimal division of the Babylonian units was combined with the Egyptian twenty-four hour system. They made more progress, observed and recorded the apparent motions of sun, moon and the planets, but hardly formulated any theory to account for their movements. It is here where the Greeks and the Indians showed their genius.

Anaxagoras, who was born about 500 B.C. near Smyrna, left his possessions in order to study science and went to live at Athens. It was he who first discovered* that the moon has no light of its own, but shines by reflecting sun's light. With Anaximenes he correctly accounted for the eclipses of the sun and the moon. He also gave some fruitful ideas about the nebular hypothesis on which our present cosmological theories are based. He, at the

same time, conceived that there are other worlds like ours; but apart from these ideas he hardly made any advance upon the crude astronomy of his time. Both Leucippus and Democritus, who formulated the atomic theory followed the views of Anaxagoras and made no advance in the astronomy of their time.

About half a century later, Aristotle supported Eudoxus and Callippus and regarded the universe as spherical in shape and finite. It was about 200 B.C. when Aristarchus (310-230 B.C.) first gave the heliocentric idea of the astronomy of his time.[†] The historian Plutarch says that for giving a pagan's hypothesis of our universe he should have been indicted for impiety; but since the leading mathematicians of his time like Archimedes and Seleucus did not preach against him, no action was taken. Perhaps nobody cared to know his impious declaration.

It was however Hipparchus who totally discarded Aristarchus's heliocentric hypothesis and adhered to the prevalent geocentric system. He made accurate observations of the heavens, his greatest achievement being the discovery of the Precession of the Equinoxes. He also calculated the length of a year as 356- $\frac{1}{4}$ days. Based on his extensive observations Ptolemy, who wrote his famous *Almagest* in about 150 A.D. held the field till the time of Copernicus who later supported by Galileo, Kepler and Newton, changed the entire conception of the universe.

Later Development

Aryabhata I was perhaps the first mathematician who, having based his ideas on the teachings of the sage, Parasara, propounded his astronomical system but the author of the extant *Aryabhata* that deals specially with

* In India Aryabhata conceived that same idea of the planetary system, but he did not dare go against the general belief of his time.

† The present writer does not think that either Aristarchus or Copernicus got the heliocentric idea from India; but Heraclides of Pontus was certainly foreshadowed.

mathematics and astronomy, is likely to be another Aryabhatta whose astro-mathematical works, known as *Arya-Siddhanta*, lived at the end of the fifth century A.D. He was a great inventor who boldly discarded all astrological predictions and sought to reform astronomy on scientific principles.

It may be mentioned here that Aryabhatta, like Aristarchus of Samos who had boldly rejected Eudox's vortex idea, maintained the idea of the rotation of the earth round its axis and gave the idea that a similar phenomenon would happen if the sun was regarded stationary at the centre, and the earth and other planets were to revolve round the sun. His estimate of the earth's circumference was not very wide of the mark. For the purpose of calculations, however, the planetary system was taken as geocentric and the later astronomers accepted this idea.

The younger Aryabhatta was followed by Varahamihira who was probably born in the beginning of the sixth century A.D. He was an all-round scientist who wrote several well known works of which the *Pancha Siddhanta* treats both astrology and astronomy that include the computation necessary for finding the position of a planet. He discussed the sphericity of the earth and subsequent astronomers followed him. Alberuni translated two of his works into Arabic in 1000 A.D.

It is said that while summarising his astronomical theses, he was helped by some Scythian Brahmins who were well versed in Babylonian and Greek astronomy. It is very speculative on our part to say how far the great Indian astro-mathematician received his astronomical information from the Middle East countries. It is also possible that the same type of ideas has originated in different countries much at the same time, as we find in the case of the independent discovery of oxygen in different Western countries—France, England and Sweden.

Another prominent Indian astronomer was Brahmagupta (born 628 A.D.) who lived at Ujjain, then a great astronomical centre of India. It is said that unlike his great predecessor of encyclopaedic knowledge, he was a more original thinker who separated astronomy from astrological speculations although he had made various astrological charts and reformed astronomy on scientific lines.

It is recently said that he invented the quadrant (*Turya Yantra*) for astronomical observations and applied algebra to astronomical calculations. In a few decades the Caliphs of Baghdad made use of this scientific invention in their astronomical observatories.

A few centuries later, although the Medieval Age had set in India, there was born in 1114 A.D., a world-renowned astro-mathematician of prodigious scholarship, popularly known as Bhaskaracharya, who also worked at Ujjain. His treatise, known as *Siddhanta-Siromani*, contains: (i) astronomy, (ii) arithmetic and mensuration, known as *tilavati*, and (iii) *bijaganita* (algebra). In his studies on the earth he gave its diameter as 7905 miles and mentioned its attractive power, thus forestalling Newton by several centuries. He also determined with considerable accuracy the positions of the sun, the moon, and the planets in terms of their positions on March 19 1520.

Like the Buddhist monks there was a host of Indian astronomers who did missionary work in Middle East countries. For instance, patronising the Persian school of astronomy, the Second Caliph, Al-mansur, in 723 A.D., invited to his court the renowned Indian astronomer, popularly known as Manaka, who gave various tables of equations of planets according to their motions with observations relative to both solar and lunar eclipses, as well as the ascension of the signs. It is also said that the illustrious astrologer, Abu Mashar of Balkh, depended much on

another Indian astronomer well-versed in the science, learnt from him the great cycle of 'kalpa' and applied it for his astrological calculations. Besides, Brahmagupta's two well known astronomical works, *Brahmasphuta Siddhanta* and *Khandakhadyaka*, were translated into Arabic and named as *Sindhind* and *Arkand*. They exercised great influence in imparting scientific knowledge of astronomy in the country, and the great mathematician, al-Kanaurizi, further developed the Indian astronomical system in his country. A few years later another Saracenic mathematician, al-Kindi, laid stress on the use of Indian numerals and astronomical tables. The Third Caliph, Harun-al-Rashid, set up a House of Wisdom for the translations of Greek and Indian works the chief translator being the Nestorian Hunaya-ibn-Ishaq (809-877 A.D.) and also founded an astronomical observatory at Baghdad with the help of Indian astronomers.

For a few centuries however, Baghdad remained the great centre of mathematical and astronomical studies. Religious tolerance and official patronage kept alive an active interest in Nature, but her golden days did not last long, for the Mongols soon overran the Middle East, and in the twelfth century sacked Baghdad. From the thirteenth century onwards, Mohammedan power began to decline, and rational enquiries in science and philosophy were condemned as corrupting the truths of Islam. The scientific tradition in the Saracenic countries began to dwindle and their knowledge was taken to Europe.

Like her renowned neighbour, India's days of glory were also numbered, and although, for some centuries, great mathematician and astronomers like Bhaskara made valuable contributions, their outlook was, like Newtons, chiefly theological. In the thirteenth century practically the whole of northern India was over run by the bigoted Pathans,

and the educational institutions like Nalanda and Vikramashila were razed to the ground. Like the Islamic world India also sank into oblivion

Generalization

The early cosmology in India, like that of Greece in her golden age (500-300 B.C.), took the form of dramatic historical fables known as *Puranas*. In the beginning, the heavenly bodies were regarded as gods, but during the later period attempts were made to explain the structure and behaviour of the heavenly bodies in scientific terms. The *Upanishads* put forward theories of natural happenings and have thus laid the foundations of philosophical science. As a result the different schools which started in with vague ideas of creations gradually brought general scientific theories into precision; but unfortunately, scientists like Patanjali gradually lost faith in themselves, and their methods of thought changed direction. They began to doubt more and more if scientific enquiries alone could unfathom the workings of the universe, and gradually the centre of gravity shifted from natural philosophy to unaccounted Divinity. The heavenly bodies thus again came into prominence and became objects of worship, as they had been before in Egypt and Babylonia. Astronomy thus became more subservient to astrology than to physics and dynamics. As a result, a sophisticated kind of heaven-worship began to replace the rational speculations about Nature, and a faith in divination began to revive, but in India the spirit of rational investigation soon returned a few centuries after the Christian era, and her astronomers showed definite superiority over her celebrated rival (Greece) in calculating the solar year and in recording the progress of the moon through the sky with an accuracy which was not surpassed until

the seventeenth century A D In 1787, J.S Bailey* published his treatises about the great antiquity of the Hindu astronomical system. He believed that their calculations, made from time immemorial, were infinitely more exact and natural than those of Ptolemy and that the Greeks of Alexandria had profited by the Indian thoughts, but had mutilated their results. Bentley, on the other hand, holds a different view

For the purpose of astronomical calculations the planetary system was taken as geocentric, although it was suggested in India long before Aristarchos that the earth revolved round the sun and also rotated round its axis. The true cause of solar and lunar eclipses were also properly explained, and the occurrence of both the eclipses were forecast with great accuracy. The later astronomers like Varahamihira, Samudragupta, and Bhaskar also accepted the heliocentric idea, but did not bother to preach it to the public. In short, the Indian astronomical formulations were more reliable than those of the Graeco-Roman world for all practical purposes

Conclusion

In summarizing it may be stated that unlike the Babylonians and the Egyptians who only cared for the continuity of their astronomical records for the maintenance of a reliable calendar, the Indians of antiquity went deep into the matter and tried to theorise all the natural phenomena which they had

come across. Their astronomy has three definite phases: (a) Vedic Astronomy, which is unscientific, (b) Vedanga, Jotisha which is formal but crude; (c) Siddanta Astronomy, which is highly intellectual. No doubt, some of the astronomical problems of the present time were not clear in those days; but the Indian astronomers did lay the foundation, the generalizations on which during the sixteenth and seventeenth centuries became the main feature of the rapid development of astronomy in the West. To be brief, astronomy and mathematics led the way and physics followed it in the seventeenth century. Chemistry moved forward in the eighteenth century, biological sciences in the nineteenth, and atomic science in the twentieth century.

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* Jean Sylvain Bailley was the first mayor of Paris and President of National Assembly in 1789. He was born in 1736 and guillotined in 1793

Position of General Science in Indian Schools

ASOK SINHA AND BINA GHOSH

Saha Institute of Nuclear Physics, Calcutta

SCIENCE plays an important role in a developing country. The new inventions of science and its technical applications can bring prosperity and happiness both in collective and individual life. The national economy of a country depends on her industrial progress which in turn solely depends on the cultivation of science in the country. Domestic amenities, large defence arrangements, self-sufficiency in food, industrial advancement i.e. in all spheres of life, science plays a dominant role.

But the development of science is intimately connected with the science education prevalent in the country. As a skyscraper rests on the plinth, the industrial progress of a country is shaped through science education in a classroom. A society without broad base for science cannot emanipate itself from stagnation and starvation. Science is again an ever-developing discipline. There is therefore a constant need to orient and modernise the system of science education in the country.

After independence, eminent educationists in our country were seriously thinking of modernising the system of science and mathematics teaching in our schools. This was necessary for improving the standards at the college and university. Science in all branches is expanding rapidly these days. To keep the young students abreast of the new ideas and concepts and their applications to modern life, the orientation of the present system of science teaching was felt. Progressive countries like U.S.A., U.S.S.R., U.K., Australia and some other countries planned and modernised their systems of school teaching. Some of them have been working for the last fifty years. The striking feature of these attempts were that the university professors, professional scientists, school teachers and educationists of other spheres of life worked to improve the standard of school teaching in their respective countries.

The object of the present report is to study and analyse the existing school syllabi of general science in elementary and middle schools of different states of India. An attempt at analysis should be guided by certain principles—some of which are given below:

- (a) Logical development of the subject avoiding isolated topics.
- (b) Selection of concepts to be in conformity with the common inquisitiveness of children.
- (c) Presentation of the subject matter should further excite their inquisitiveness.
- (d) One branch of science should have broad relation with other branches. No attempt should be made to present each branch as an isolated compartment.
- (e) Examples should be quoted from the environment.
- (f) Equipments designed for class ex-

periments should be cheap and simple and also suitable to Indian economic and social conditions.

We shall now discuss and analyse one by one the competence and adequacy of each syllabus in the light of general problems and guidelines stated above.

It is found that the general science syllabus for each class has been divided into several major concepts. A class-wise analysis of the syllabus of each state is given below

I. ANDHRA PRADESH

Class VI—Air; water; food, personal cleanliness.

Class VII—Heat, light, clothing; fields and gardens, life in a pond

Class VIII—Health, first-aid, matter; force; light, the solar system.

II. ASSAM

Class V—Observation and identification of some heavenly bodies; plant life; animal life; health and hygiene, civil duties

Class VI—Earth's crust, the state of Assam and its administration; general classification of plants; general classification of animals; human body; transport rules, accidents and first aid.

Class VII—Physics matter and its three states, physical properties of air and water, effect of heat on water; evaporation and condensation; effect of heat on air ventilation; effect of heat on solids. Pendulum; thermometer. Transference of heat; thermoflask. Energy and its transformation. Chemistry — characteristics of chemical compound; combustion and rusting of iron.

Astronomy—the sun, its dimension and distance from the earth; planetary system and relative positions of the planets.

Class VIII—Light, magnetism, electricity, air and its composition, water and its composition; characteristics of chemical compounds, the earth; the story of coal and mineral oil, eclipses.

III. BIHAR

Class V—Cleanliness at home, wholesome food; value and need of fresh air; impurities in water; insects; plant life; birds, soil. Observation of stars; maintenance of weather chart

Class VI—Manuring of fields and rotation of crops, germination, elementary idea of human body, principles of First-Aid, Air; water; necessity of bath; advantage of pulley system, magnet, the moon and the earth, simple experiments of reflection and refraction of light; common balance, spring balance, liquid seeks its own level, maintenance of weather chart

Class VII—The human body; practical understanding of the principle of first-aid; common diseases and preventive measure; water, distinction between elements and compounds, thermometers; sources and measurement of heat.

IV. BOMBAY

Class V—Things about ourselves

Our body and health—our senses; care of the eye; ear and tooth; physical exercises. Things around us

Air—it occupies space, it has weight, air in motion—winds and storms; air and health—ventilation

Water—sources of water; water cycle; water as a maker and distributor of soil, water in motion—floods, irrigation, canal, facts about flood damages in India. Plants, birds insects and animals—recognition of crops, trees in their neigh-

bourhood from their roots, leaves or flowers etc.; effects of seasons on plants, birds, insects and reptiles.

Things under us

Collection of a few types of rocks and soil in the neighbourhood; water and rocks, heat and rocks; fossils

Things above us

The sky—the sun, the moon, the pole star; general idea of the relative distances between the earth, the moon and the sun.

Class VI—Things about ourselves

Our body and health—breathing; food as a fuel for human body.

Things around us

Air—temperature of air, water and human body; how temperature is measured in Fahrenheit and Centigrade scale; pressure of air; moisture in the air; weather.

Water—properties of water; three states of water; clouds, fog, dew and rain, plants, birds, insects and animals—functions of various parts of a plant and their adaptation to environment; useful and harmful insects to agriculture *Fire*—fire as a source of heat; fuel; danger from fire, how to avoid.

Things under us

Under the earth's crust—collection of minerals found in the neighbourhood; information about manganese, coal, iron, aluminium, copper and their uses; the recognition of these and their alloys.

Forces underground—entrapped water; underground water and heat; volcanoes, how earthquakes are caused springs—hot and cold.

Things above us

The sky—the moon and its phases, solar system

Class VII—Things about ourselves

Our body—balanced diet, digestive system; sanitation, conquest of diseases

—symptoms of common diseases, minor ailments in school children.

Things around us

Air—putting air to work—wind mill, common pump, football inflator, important gases in air, their proportion and their importance, causes of impurities in air; preparation of C_2 , O_2 , and N_2 in the classroom; chief properties of these gases; air dissolved in water; CO_2 solution—soda water. *Water*—moisture in air, rusting of iron and its protection

Plants, birds, insects and animals—information of three birds regarding general-size, colour, mode of flight, nesting, food brooding season, form and colour of eggs, migration; breathing of animals and plants. How do plants prepare their food?

Fire—control of fire; fire safety

Simple machines—lever and its applications; friction; frictional electricity.

Things under us

Matter—matter, three states; change of state; building materials.

Life under water—river plants and animals, fishes.

Things above us

The sky—the sun as a source of energy; study of three bright stars; light rays—their properties, plane mirrors.

Class VIII—Things about ourselves

Our body and health—clothing, body temperature, clinical thermometer; normal temperature of man, animals and birds; clothing material—cotton woolen and silk; accidents, emergencies and first aid, how we speak; common speech defects—how they are overcome

Things around us

Air—airships and balloons; use of hydrogen and helium; how kites, aeroplanes fly. Atmospheric pressure—vacuum and partial vacuum; vacuum brakes, vacuum cleaner, atmosphere at

different heights—on mountains and in the mines. Water—density and its determination; specific gravity bottle; U-tube, Haie's apparatus. Natural and artificial magnets, poles and their action, magnetisation by single touch.

Rectilinear propagation of light, shadows and eclipses; reflection and its laws, formation of images by plane mirrors. Two kinds of electricity and their action.

Power—general idea of sources of power—sun wind, water, oil, steam and electricity, steam engine, water turbine, motor car engine, electric motor.

Friction—charge on the outer surface, leakage of electricity from a point; lightning conductors. Simple machines—pulley, wheel and axle, screw—use in life.

Matter—examination of common substances, methods of purification of matter; general idea of elements mixture and compound.

Life under water—substances obtained from sea-salt, iodine, pearls, fish, oils, sea life, floating, diving.

Things above us

The sky—the milky way; meteors and comets, stories about great astronomers, use of telescopes. Measurements Length, mass, time and their basic units, area of rectangle, triangle and circle, volume, use of measuring jar, burette and pipette.

V. DELHI ADMINISTRATION

Class V—Living things; non living things, principal constellations in the sky, food; health and hygiene, human body, effect of air on life, effect of water on life, sources and effects of heat.

VI. GUJARAT

Class V—Air: necessity, breathing; water. sources, impurities, purification, washing. *Food*: necessity, kinds and constituents of Food, Movements: study of movement in plants and animals. Senses: the eye, comparison with simple camera, care of eye.

Study of the sky. the pole star, other stars, planets and milky way.

Class VI—Air, study of constituents, water, cycle of water (evaporation, condensation, rain).

Food: process of digestion and assimilation necessity for growth; blood, its constituents and circulation, maintenance of uniform body temperature; clinical thermometer, proper methods of eating, excretory system, sanitary care, manure soil and its effect on food.

Movements: muscle movement, balance and centre of gravity, inclined plane, mountain road, levers in everyday experience.

Senses: light produces colour, pigment in skin, protective colouration on animals, value of sunlight; structure of ear, how sound is produced, echo.

Study of the sky: planets and planetary system, eclipses.

Class VII—Air. breathing, pump and syringes, air pressure, impurities of air and purification germs and bacteria, air borne diseases;

Water. water borne diseases, prevention and cure; proper distribution of food, sanitation.

Food: difference of food according to age, occupation and climate, diseases due to improper food habits, contamination of food, preservation of food. Movements: wheels, chain in a cycle, gear, friction and lubrication.

Senses: touch, taste and smell; the brain, the nervous system, skin, diseases by contagion, prevention and cure

Reproduction: how life is passed on in plants, animals and human beings:

Study of the sky: the solar and lunar systems of calendar, intercalary month

Class VIII—Air: constituents, purification, effect of sunlight on air, artificial and natural ventilation and respiration, atmospheric pressure, barometer mountaineering, combustion, exhaled air, organs of breathing, study of respiratory system, respiratory ailments;

Feeding: food; raw and cooked, nutrition, organs of digestion, excretion, organs of excretion;

Soil: type of soil, manures; grow more food; personal hygiene.

Movement: movements of human body and other animals; how light travels, reflection and refraction; how heat travels, everyday application of principle of transference of heat; magnets.

VII. KERALA

Class V—Animals; dispersal of seeds, plant, health and hygiene; first and some common substances, air and burning, composition of air, water and air pressure, water finds its level, heavenly bodies, the solar system, stars and constellations, plants

Class VI—Birds, plants, fertility of soil, the human body, limestone and carbon dioxide, heat, expansion of solid, liquid and gas, change of state; conduction; convection and radiation, the crust of the earth.

Class VII—Animals, adaptation of feeding, locomotion, means of protection, social life, life history of some insects; plants adaptation, life-span; human body, food,

digestion, respiration excretion, some common things of daily use; light, shadow, image, convex lens as magnifying glass, rainbow, magnetism and electricity, heating and magnetic effect of electric current, magnets producing electric current, dynamo

VIII MADHYA PRADESH

Class VI—Water, importance, sources, three states; use of steam; James Watt, railway engine, impurities of water; plant and animal life; heat—sources, method of production; effect; expansion of solid, liquid and gas; practical application, conductors and insulators of heat Machines, railway train, motor car, telegraph, telephone, ships, submarine, balloon and air ships. Measurement of length, area, use of graph paper. Solution, solute, solvent, saturated solution, mixing, solution, dissolving gases in liquids.

Crystallisation, preparing crystals of sulphur, effects of heat on crystals, crystalline substances.

Class VII—Air—constituents, humidity, dust, burning of substances, rusting of iron. Plant and animals. Heat—temperature, thermometers, freezing and boiling points, transmission of heat. Three states of matter, effect of heat on different substances. Decantation, filtration and crystallisation; volume—its unit and measurement Mass and weight; gravity, balance; levers; density and its measurements, elements, mixtures and compounds.

Class VIII—Air—pressure, barometer, pumps, siphon Water—need by plant and animals, hard and soft water, removal of hardness. Plant and animal Heat—conversion of temperature from one scale to another Electricity by friction, positive and nega-

tive charge, conductors, insulators, atmospheric electricity, experiment of Benjamin Franklin, lightning and its protection, voltaic cell, dry cell, battery; flow of current—lamp, torch, heater, bell electroplating. Pressure due to liquid, upward and downward thrust, city water supply, fountains. Archimedes' principle relative density, lactometer, submarine, properties and uses of hydrogen. Nitrogen cycle, carbon and its properties and uses of soda water, fire extinguishers, carbon dioxide cycle, acid, bases and salt. Manufacture of matches.

IX. MADRAS STATE

Class VI—Food—needed by plant and animals for growth and work, common food of man, wholesome nutritious food, vegetables, milk; food habits of local animals from the point of view of structural adaptation, cooking of food. Breathing—respiratory organs in man, ventilation. Life history of house-fly, mosquito, frog and silk moth. Modes of travelling on land, sea and air by man. Maintaining physical efficiency and healthy living—food, exercise, sleep, air and sunshine, clothing and cleanliness. Safety in walking on the road. Building home—building materials—lighting, ventilation and cleaning. Air—necessary for breathing and burning. Animals—vertebrates and invertebrate. Growth of plants—soil, climate and sunlight. Different kinds of soil. Tilling—fertilizers and manures—rotation of crops—adaptation of plants. Three states of matter; light—source, relation of life, sense organs and their connection with brain through nerves.

Class VII—Food—composition—mixed and balanced diet, alimentary system in man—digestion, assimilation and excretion.

Breathing through nose; respiration of plants. Growth of plants from seeds—propagation of plants, migration of animals. Main bones and muscles in man. Skin and its function—its care and diseases, the excretory system in man. Protected water supply and milk supply, purification of drinking water. Building materials. Air—its composition, expansion of bodies when heated, temperature, thermometers, adaptation of animals. Water finds its level. The nervous system, the wheel and axle, steam engine, water falls, water wheels, wind mill, lift pump. Cast iron, wrought iron and steel.

Class VIII—Food habits of local birds, soil and food supply to the plants. Breathing organs. Flowering plants, fruits and seeds; first aid, fire engines, fire extinguishers, burning and rusting. Sun, stars, sunspots, meteors and comets. Transmission of heat, elements, compounds and mixtures. Eye—its defects. Sun—source of energy—photosynthesis. Gravity, centre of gravity, conditions of equilibrium, the ear. Sound—production, transmission, echo, musical instruments, the vocal chords. The radio—how it works.

X. MYSORE

Class V—Air—breathing and burning, respiration in man, fish and plants, impurities of air. Water—sources, impurities, purification, pollution and disinfection. Food—necessary for growth and work—diets for children, adults, sick and manual labourers, preservation of food. Home, building materials, cleanliness, ventilation. Simple machines—lever, pulley, inclined plane, wheel and axle, friction and lubrication. Transportation—

discovery of wheel. Different kinds of power used—animal, steam, petrol, electricity.

Class VI—Air—composition, purification. Water—uses, water cycle in nature, water finds its own level, water supply in towns. Food—composition, balance diet milk and egg; drinks, effects of alcohol on health. Digestive system in man. Photosynthesis in plants. Home—cleaning, sources of light—sun, oil, electricity; nursing the sick. Transportation by land, sea and air. Compound machines—bicycle, sewing machine.

Class VII—Air—properties, pressure. Water—hard and soft, softening of water. Blood—circulatory system. Plants—dispersal of seeds, cross pollination, grafting; heat—sources, effects, expansion change of state. Temperature, thermometers. Communicable diseases. Communication—post, telegraph, telephone, radio, etc. Eye—main parts, defects, removal of defects and proper care. Ear—main parts, proper care.

XI. ORISSA

Class VI—Different domestic and neighbouring animals, human body. Air—impurities, ventilation, importance of fresh air. Water—sources, pollution and purification for drinking. Cleanliness.

Class VII—Plants. germination, dispersal of fruits and seeds. Food: necessity and ingredients of food, balanced diet; sun and planets. Personal hygiene, cause and prevention of common diseases, nursing.

Class VIII—Difference between plants and animals. Flowering plant. Measurement of length, area, volume and mass; three states of matter. Archimedes' principle, floating of ships, aeroplanes and balloons.

Separation of mixture, solution filtration, crystallisation, distillation, sublimation.

XII. RAJASTHAN

Class V—Necessity of air for humans and plants, importance of fresh air. Root and stem plants in neighbouring locality. Fly and mosquito. Seasons and seasonal crops. Dew, fog, snow, cloud formation, difference between mist and fog, rainbow. Difference between pure metal and alloy. Knowledge about different metals and other chemicals. Three states of matter.

Class VI—Skeleton of human body; constituents of food; balance diet—vegetarian and non-vegetarian. Different types of plants, root, stem leaf. Difference between living and nonliving, properties of matter. Measurement of length, area and volume; gravity, mass and weight, physical and spring balance, simple machines as levers, knife and razor, pulley and screw. Density. Heat—a kind of energy, production and source of heat; effect of heat on solid, liquid and gases; change of state, thermometers; matter and its chemical properties; heating and cooling. Squeezing of simple juice, solute, solvent, solution; solution of gases in liquids. Removal of spots and dry washing, crystallisation, physical and chemical changes, burning and rusting elements and mixtures, separation of constituents of a mixture. Solar system, minerals of the earth. Rocks.

Class VII—Blood circulation and respiratory system; kinds of diseases, cause of skin diseases and their prevention. Fruit, flower and their work, pollination, germination, dispersal of seeds. The systematic development of creatures on the earth. General properties of matter, specific gravity.

Archimedes' principle, floating and sinking, hydrometer, lactometer, balloon, submarine. Water finds its own level, pressure of gas and liquid, barometer, siphon, pumps, clinical spray, fountain pen; stove. Heat—production, propagation, ventilation. Light—a kind of energy; pin-hole camera, shadow, solar and lunar eclipses, reflection. Preparation and study of properties of hydrogen and oxygen, carbon and its allotropes, presence of carbon in nature; carbon dioxide cycle, soft and hard water. Extraction of matters and their classification as metal and non-metals. List of minerals.

Class VIII—Physiology and hygienic science excretory system and diseases. Friends and enemies of farmer; fungus and bacteria of different diseases of plants, Darwin's theory. Steam and its energy, steam engine. Refraction of light, spectrum, rainbow; production of sound, method of hearing, sound waves, simple idea of gramophone; characteristics of magnets, natural and artificial magnets, compass, two kinds of electricity, thunder and lightning, lightning conductor, dry cells and torch; heat, light and magnetism produced by electricity, simple electric circuits, house wiring electric bell, wire, iron heater etc; general idea of radio and x-ray. Acid, bases and salts; simple idea about molecule, atom, electron, proton; minerals in Rajasthan; origin of earth.

XIII. TRIPURA

Class V—Animal—vertebrates and invertebrates, toad. Reproduction system of plants, night sky—Nebula, milky way, comet, meteor, constellations, Polestar direction finding. Weight, gravity; constituents of air, importance of oxygen and carbon dioxide in plant and animal life.

Respiratory and digestive system, protection from insects, first-aid, contagious diseases, vaccination, inoculation, etc.

XIV. UTTAR PRADESH

Class VI—Levers; measurement of volume, centre of gravity, weight and mass, spring balance, physical balance. Air—its constituents, ventilation. Water—absolute solvent, purification, distillation; sources of heat; effects of heat, thermometers, natural and artificial magnets, general properties of magnet, general properties of matter; enemies and friends of agriculture, habit and suitability of fish, domestic pets, human physiology, digestive system, monocot and dicot seeds, simple modification of roots and seeds according to their functions.

Class VII—Pulley; pressure of air, barometer; density; preparation of carbon dioxide and oxygen, their properties and uses; solution, saturated solution, crystallisation, vanishing of sports; transmission of heat and uses, frictional electricity, conductor general properties of carbon and copper, friends and enemies of agriculture, habits and suitability of earthworm. Human physiology, kidneys lungs, skin, lever.

Class VIII—Wheel and axle, inclined plane, nail and screw, simple pump, bicycle and football pump, siphon. Pressure of liquid Archimedes' principle, floating and sinking, balloon and submarine. Lactometer; relative density; acid, base and salt; hard and soft water, method of removal of hardness of water; sources of light, straight line propagation of light, pinhole camera, eclipses, reflection of light, Kaleidoscope; refraction; dry cell, heating lighting and magnetic effect of current, house wiring, fuse, heater, iron, bulb

The Gardens and Parks of Delhi

G. S. PALIWAL

Department of Botany,

University of Delhi,
Delhi

THE twin cities of Delhi and New Delhi have a sub-tropical location (Lat. $28^{\circ} 35'$ N, Long. $77^{\circ} 12'$ E) in the Indo-Gangetic Plain, on the fringe of the Thar desert. The average elevation of this territory is 700 ft above sea level and the rainfall is low ($26''$ — $28''$ annually), received mostly during the monsoon months. In fact taking average figures for the whole year, only 10 per cent of the days are wet. The summer is scorching hot with temperatures shooting up to 46° C, and with frequent dust storms. The winter is severe and the mercury sometimes approaches zero. There are three marked seasons in the year: the rainy season (July-October), winter (November-February), and summer (March-June).

River Yamuna enters Delhi area from the north and leaves it in the south-east. A spur of the Aravalli Hills lies diagonally

across the city, extending in the south-west—north-east direction. This constitutes the so-called Delhi Ridge. Also, there is the southern or New Delhi Ridge which adjoins the Presidential Estate (Rashtrapati Bhavan Area) and the Birla Temple. Portions of both the ridges have been quarried for laying roads and erecting buildings.

Owing to differences in soil type and the availability of water, a variety of habitats prevail, and several vegetational types can be distinguished. The major ones are: (i) the vegetation of the Ridge, (ii) the vegetation of the low-lying area, (iii) the vegetation of the riverine areas, and (iv) the cultivated plants. In the present article it is intended to describe the plants growing in the gardens and parks, which beautify this cosmopolitan city, 77 sq. m. in area with a population of about 3 million.

On account of its political importance since the days of Mahabharata (*ca.* 2500 B.C.), the populace has been noted for its love of parks and gardens. This art has developed more rapidly after independence. By the large number of flower shows arranged every year, it appears that during the recent past the people have become more garden-minded.

Different trends can be witnessed in the development of gardens and parks. The influence of the Mughal, European and even Japanese designs of layout is evident in the public gardens such as Qudsia, Nicholson, Qutab, Roshan Ara, and those associated with the historical monuments. In these one finds an abundance of evergreen forms along with asparagus, crotons, jasmines, rangoon creeper and other creepers, and the best quality of Bela, Jui, Mogra, Calendula, and Henna are grown in plenty.

The avenues of New Delhi are famous for their artistic patterns. Several flowering trees beautify the roads, housing areas, traffic squares and circuses; they also give a very

soothing shade during the summer. In winter several traffic islands are decorated with multi-coloured, gorgeous seasonals such as the chrysanthemums, gerberas, phloxes, violas, and verbenas. Hardy plants such as *Asparagus*, *Rhoeo*, *Zebrina*, and even *Bougainvillea spectabilis* can also be seen in hanging baskets adding glamour to the busy roads. The trees *Pinus roxburghii* add charm to the famous Vijay Chowk.

The common avenue trees are: *Ailanthus excelsa*, *Azadirachta indica*, *Bauhinia variegata*, *Cassia fistula*, *cassia renigera*, *Dalbergia sissoo*, *Delonix regia*, *Eucalyptus* spp., *Ficus Krishna*, *Ficus religiosa*, *Grevillea, robusta*, *Heteophraragma adenophyllum* sp., *Jacaranda mumsaefolia*, *Kigelia pinnata*, *Lagerstroemia speciosa*, *Mangifera indica*, *Melia azedarach*, *Millingtonia hortensis*, *Mimusops elengi*, *Polyalthia longifolia*, *Pongamia pinnata*, *Putranjiva roxburghii* and *Terminalia arjuna*.

The gardens, such as the Buddha Jayanti Park, Lodhi Gardens, Rajghat, University Campus Gardens, Corporation Park, Talkatora Gardens and those in the new residential colonies, most of which have been developed after independence, show diverse blends of colourful foliage and flowers. Here one can come across different species representing both tropical and sub-tropical vegetation.

The Vice-Chancellor's Avenue in the University Campus is decorated by *Polyalthia longifolia*, with its long, shiny, evergreen leaves. The parks on both sides of the Rajpath (New Delhi) are adorned by *Syzygium cerasoideum*. Its semi-globose compact crown and light green leaves have a soothing effect on the eyes. In many gardens *Mimusops elengi* has been grown because of the mild fragrance of its white flowers which is very refreshing. Other common avenue plants are *Biota orientalis* and *Roystonea regia* which are generally grown in rows.

Perhaps the best kept garden in the country

is the one associated with the President's Estate. It is open to the public only during the months of January and February, and a visit at that time is a memorable event of one's life. One sees here an excellent collection of winter annuals. The terraced garden with a central oval pond, the carpet-like lawns, the majestic thujas, the flower-laden *Pyrostegia venusta*, the unending varieties of flowering herbs, the well-trimmed citrus bushes, the red-stone covered paths, and the many fountains make the garden a paradise. No wonder, therefore, that this garden has featured in several coloured movies. The great interest of the late Dr. Zakir Husain in gardening further added to its grandeur.

Rajghat, where the mortal remains of Mahatma Gandhi the Father of Nation, were finally laid to rest—has become a 'must' for almost every dignitary visiting the Indian capital. Several VIPs have planted saplings in memory of their visit and in homage to this champion of liberty. Avenues of *Eucalyptus lobosus*, with their mild warming spicy odour, Chandelion trees (*Kigelia pinnata*) and the dark green *Pongamia pinnate* provide a very attractive appearance: a synthesis of serenity and simple yet uplifting atmosphere. Handsome shrubberies are interspersed in the garden, and colour is present all the year round. The two other samadhis—that of the first Prime Minister, Jawahar Lal Nehru, the SHANTI VANA and the other of his successor, Lal Bahadur Shastri, the VIJAY GHAT—are still in the early stages of their development. From the layout plans, however, one gets a good idea of the sombre picture that will emerge in due course.

An extremely well maintained garden is that of India International Centre in Lodi Estate. *Adenocalymma*, *Alstonia*, *Araucaria*, *Bauhinia*, *Beaumontia*, *Bougainvillea*, *Callistemon*, *Chikrasia*, *Delonix*, *Eucalyptus*, *Jacaranda*, *Lonicera*, *Plumeria*, *Thunbergia*,

of hexane and benzene. Why does mercury have such a high value, and fluoro-carbons such a low one? Is it the nature of surface atoms or their orientation at the surface which matters? Which part of bifunctional molecule concentrates on the surfaces, the more active functional group or the less active hydrocarbon part?

Surface tension has long been regarded as a direct measure of the intermolecular forces. Probably, it is one of the simplest method of determining the intermolecular forces. But what type of forces are involved in making the tension existing of the surface? Is the contribution of various type of forces additive or mutually exclusive?

From our present knowledge of various kinds of forces, we know that the intermolecular forces in saturated hydrocarbons are only dispersion forces. Everyone knows the *Van der Waals* forces—the forces which make even permanent gases, liquify at low temperatures and high pressures. Obviously these forces are short-range forces. Unlike columbic forces, they do not vary inversely as the square of the distance but as 6th or 7th power of the distance, which means that surface forces cease to exist beyond a distance of 10^{-8} or 10^{-7} cm from the surface and that the thickness of the surface layer is of the same order.

Now these *Van der Waals* forces arise from the interaction between;

- (a) permanent dipoles of molecules;
- (b) permanent dipoles and induced dipoles,
- (c) instantaneous dipoles and induced instantaneous dipoles, etc.

In case of inert gases, type (c) interactions are responsible for their liquification. They are called dispersion forces.

Thus if we consider the contributions of various forces to surface tension as addi-

tive, we may expect the surface tensions of liquid metals or polar liquids (i.e. those which have, at least, two independent types of forces) to be made up of the two independent terms:

Water + Hydrogenbonding + Dispersion forces

Mercury = metal bonding + dispersion forces

Hydrocarbons

+ dispersion forces.

There are many interesting phenomena of both practical and theoretical importance which occur on the surface of a liquid.

Surfaces of solids

The concept of surface tension of solids is difficult to visualize, as the visible characteristics observed in the case of liquids are not observed here. In a liquid, molecules from the bulk phase can enter or leave the surface as it expands or contracts, while in the solid, any such movement will result in the variation of inter-atomic distances resulting in strain. In simple words, we can say that the surface of a liquid is smooth or to use a more technical term, homogeneous, whereas the surface of a solid is rough or heterogeneous. Liquid drops tend to assume the shape of minimum area i.e., spherical, while solids tend to crystallize i.e., have sharp corners, edges, boundaries, etc.

The shape and position of a liquid in a capillary is a function of its surface tension, but same is not true for solids. Thus the observable manifestations of surface energy in case of liquids and solids are very different. Surface energy of solids reveals itself in phenomenon like wetting, spreading, lubrication, absorption, corrosion, etc. One interesting method for determining the surface tension of solid is the wire-suspension

method. A fine single crystal wire is used to support a weight, as temperatures near the wires' melting point. At such temperatures, the mechanical strength of the wire is supposed to be negligible and the weight is almost supported wholly by the solid-vapour surface tension of the wire. If the wire is poly-crystalline, the grain boundary surface tension must also be considered.

This method has revealed that there is no drastic change in the magnitude of the free surface energy of a liquid on solidification, for example:-

<i>Metal</i>	<i>Liquid at 150°C</i>	<i>Solid at 950°C</i>
Copper	1735 dynes/cm	1830 dynes/cm
Iron	1788 dynes/cm	1950 dynes/cm

Further such high values of surface energy suggest that metal surfaces are potentially very reactive. The lack of activity of many metals at ordinary temperatures is due to their being covered by protective oxide layer. Studies in electronics, catalysis and corrosion have demonstrated that it is extremely difficult to obtain a perfectly clean metal surface. Often they are covered by a mono or multilayers of loosely or firmly bound oxygen.

The tendency of a metal to react with oxygen is indicated by the free energy change accompanying the formation of an oxide. The table below lists the values for some common metals.

Free energy of formation of metal oxides (per oxygen atom) at 500°K.-in kilo-calories

Calcium	— 138.2	Zinc	— 71.3
Manganese	— 130.8	Hydrogen	— 58.3
Aluminium	— 120.7	Iron	— 55.5
Titanium	— 101.2	Cobalt	— 47.9

Sodium	— 83.0	Copper	— 31.5
Chromium	— 81.6	Silver	+ 0.6
		Gold	+ 10.5

Those showing a large decrease in free energy (negative value) are prone to quick oxidation. Among metals where oxides are stable, two general types of behaviours are observed. Alkali and Alkaline earth metals (sodium, calcium etc), form a porous oxide film, others such as iron, copper, etc, form more dense films. The thickness and growth rate of these surface films determine the degree to which the oxide protects the metal beneath it. In order to know whether the oxide films formed is porous or dense, a formula known as Pilling-Bedworth ratio is used.

$$\frac{\text{Volume of oxide formed}}{\text{Volume of metal consumed}} = \frac{M d}{a m D}$$

where M is the molecular weight of oxide, having a density 'D', m is the atomic weight of the metal having a density 'd', 'a' gives the number of metal atoms per molecule of oxide. If the ratio is less than one, the film is porous and non-protective. Oxygen can penetrate to the metal atom. If the ratio is one or more than one, the film is dense and protective. Wagner has suggested a mechanism for the oxidation of metals based upon the characteristics of the film formed.

The impurities present in metals diffuse to the surface, when metals are heated or subjected to strains and cause a tremendous change in surface properties of solids. As little as 10^{-9} moles/cm² of antimony can bring down the surface energy of copper to half its original value.

Classroom experiments

A New Approach to the Anatomy of a Leaf

SYED JALALUDDIN

R. V. Teachers College, Bangalore

It is a problem that the methods for teaching the plant anatomy are inadequate specially in high school classes. The microscope, no doubt, gives a clear idea of the anatomical features of any part of the plant-body, but often, even the use of microscopes in schools is neglected.

The leaf anatomy is the first anatomical structure that a pupil learns in high school. So it is desirable that in the beginning a pupil gets a precise concept of leaf anatomy, which forms the basis to comprehend the anatomical structure of any other part of a plant-body.

Hence a new method has been evolved for this purpose by the author of this article and is called 'the injection technique.' It is equally necessary to use a three dimensional anatomical model of the leaf in combination with this series of experiments to make the students familiar with the anatomy of the leaf.

Experiments on leaves of *Synaderium grantii*

There are three experiments which can be easily performed on the leaves of *Synaderium grantii* Hook (a small tree, family Euphorbiaceae) which is a native of tropical Africa. It has been cultivated in India. The specimen for experiments has been collected from Bangalore City proper. The essential instrument needed for all these experiments is a hypodermic syringe

Experiment I : — To show the positions of different types of cells in a leaf

Materials needed:

1. A hypodermic syringe with a hypodermic needle
2. Red ink
3. A leaf of *Synaderium grantii*.

Draw a few cubic centimeters of red ink into the hypodermic syringe. Then take a leaf of *Synaderium grantii* and hold it upside down to inject the ink into the lower part of mesophyll of the leaf through its petiole as shown in the figure No. 1(A).

The red ink will spread in various curved lines in the leaf. It percolates on only one side of the mid-rib, unless pressure is increased on the syringe, as the mid-rib tissue is compact. The colour will be brighter on the lower side of the leaf than on its upper side (Fig. 1 A & B).

The ink will not move smoothly in the

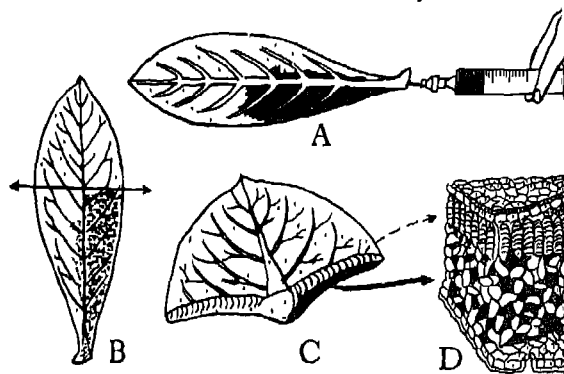


FIGURE 1

A—Injecting ink into the leaf of *Synaderium* (Lower view)

B—Upper view of the injected leaf.

C—A cut part of the injected leaf at the region marked by a horizontal arrow, showing the position of ink.

D—An enlarged anatomical structure of the leaf showing the position of ink in the mesophyll

mesophyll because of the haphazard positions of the air spaces in between spongy cells. Due to the presence of one or two layers of palisade cells the colour is not brightly seen from the upper side of the leaf. This is due to the presence of palisade cells above and spongy cells below in the region of mesophyll.

To confirm this we go to the next step.

Take the injected leaf and cut it with a blade just at the margin of the coloured area and observe the cut-end of the leaf. (Fig 1 B)

The cut-end of the leaf will have an upper green layer and a lower coloured layer (Fig 1 C)

The upper green layer shows the position of the palisade cells and proves that they are arranged compactly with less intercellular spaces. The lower coloured layer shows that the red ink occupies the air spaces in between the spongy cells (Fig 1 D). So air spaces are more in the spongy area of the mesophyll.

Experiment II : To show that stomata are present on the leaf

Take a healthy young leaf of *Synaderium grantii*, see that there are no epidermal ruptures on it. Hold the leaf upside down, one or one and a half inch below the surface

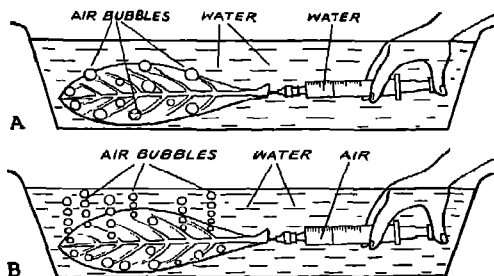


FIGURE 2

A—Injecting water into the leaf of *Synaderium* under water.
B—Injecting air into the leaf of *Synaderium* under water.

of water. Draw a few cubic centimeters of air into the hypodermic syringe and inject the air into the lower part of mesophyll, through its petiole. (Fig 2 B).

A number of bubbles will be seen coming out of the leaf. More bubbles will arise from the lower side of the leaf. Most of them will rise near the margin of the leaf in various forms.

The air comes out through the pores of the leaf. So there are stomata on the leaf. There are more stomata on the lower side of the leaf. Most of them are at the margin of the leaf-blade. Difference in the size of air bubbles indicates that there are gradings in the openings of the stomata.

Experiment III To show that there is air in the leaf

Take a healthy young leaf of *Synaderium grantii* and wash it well. Take a tray filled with water. Hold the washed leaf upside down, $1\frac{1}{2}$ inch below the surface of water. See that there are no air bubbles on it. Use a brush to wipe off air bubbles, draw a few cubic centimeters of water in syringe and inject it into the lower part of mesophyll of the leaf which is under water as in figure 2 (A).

As the water goes on spreading into the leaf some air bubbles will come out from the surface of the leaf.

There is air in the mesophyll. There are stomata on the leaf. The air is in the spaces between the cells of the mesophyll. The water occupies air spaces by displacing air, the outlet for the air being stomata.

These experiments have also been tried on other plants like *Nerium Oleander* L., a member of *Apocynaceae*, similar results have been obtained.

Let this experimental approach be useful to all teachers and let the students of the high school derive inspiration in conducting novel experiments of this kind.

Science Abroad

AIR to the Rescue

JAMES LAWRIE

IF you had the mechanical handling job of moving a heavy load over a floor or surface which was too weak to support it, or if you had to move a heavy, awkward-shaped or a very delicate apparatus over an uneven surface, would you use a Hovercraft? Perhaps not of the sea-going variety, but you could use the same principle. A Hovercraft is a vehicle that moves on a 'cushion' of air generated by the craft itself; it floats on air, so almost completely eliminating friction. The cushion enables the craft to ignore uneven water or land surfaces. The British inventor, Christopher Cookerell, defined Hovercraft as an attempt to extend the uses of a land vehicle to surfaces like the sea.

The fact that Hovercrafts are now operating in numerous places with great success, caused industry to give the air cushion principle, a long hard look and the air cushion now has some striking industrial uses. Hovercraft Development Ltd., for example, have come up with the idea of industrial lifting pads, a simple example of which consists of a frame-work to take the load, supported

on four circular lifting pads, each of which is simply a wooden base fitted with a fabric skirt and a single air feed. The skirt is shaped so that small changes in hover height will give big increases in pad area and thus stabilise loads and offset uneven ground.

Pads of 1 to 3 ft diameter can be operated up to 20 lb/in² providing up to 2 in. ground clearance. The individual pads may be placed under convenient positions at the base of the load, the factory airline supplying the pads. The load can be man-handled in any direction. The pad need not be circular and, under a framework, provide a lifting platform. An experimental unit recently demonstrated lifted a 1 ton load three quarters of an inch above the ground, clearing 3/8 inch high obstacles for an air delivery of 50 cfm at 2½ Lb/in² cushion pressure.

The question of moving really heavy loads is under investigation and it is probable that 1 to 2 ton pallet units and 20 ton containers may be lifted and easily moved by the air cushion method over normal factory floors and ship's decks.

The Elliott Aeroglide conveyor system is another application of the Hovercraft principle and consists basically of an air blower supplying low pressure air to a duct situated below the conveyor surface, a series of valves being connected to outlets in the conveyor surface. These valves, normally closed, open immediately the object to be conveyed covers their outlets, thereby supplying the supporting air under the object. The valves automatically close once the object has passed.

Objects weighing 1000 Lb can be moved horizontally by a force of only 1 Lb or they will travel unaided down an incline of only 5 ft per mile. Running costs are cheaper than those of conventional conveyor systems. Sacks, bags, bricks and concrete products, drums, flat sheets, pallets and trays can all

be handled and special 'float' tables or floors can be applied to aircraft and other vehicles.

Even the medical profession has turned to air cushioning. In cases of severe burns the pressure of bed clothes and the body pressure from lying down can be painful and retard treatment. To overcome this and so help to speed treatment and recovery of badly burnt patients, the National Research Development Council is sponsoring the development of a hoverbed in, or on, which the patient is suspended on a cushion of air, sealed on a narrow round the body.

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Crystals : Magic World

Corresponding Members of the USSR Academy of Sciences Boris VAINSHTEN, Director of the Institute of Crystallography replies to questions put by a Moscow News correspondent.

Why do scientists study crystals?

Crystals are the most perfect creation of the inorganic world. They have long been attracting man's attention. It might seem that they have already been studied in minute detail, but new discoveries are constantly being made.

"Diamond crystals are used to cut deep into the earth's crust. Crystal silicon batteries collect solar energy out in space to feed various devices in man-made satellites. The wavelength of every radio station in the world is established by means of quartz crystals. The heart of optical quantum generators—sources of light unmatched in capacity—are

crystals of synthetic ruby which have long done us good service in our pocket and wrist-watches."

"The vast sphere of semi-conductor electronics is based on the crystals of germanium, silicon and certain others. These crystals are installed in tiny transistor radios and big electronic computers which perform millions of operations a second."

"The wide use of crystals explains the interest taken in them by physicists and chemists, mineralogists and biologists, metal experts and scientists in many other spheres".

What interesting research have Soviet crystallographers carried out?

"In recent years Soviet scientists have studied hundreds of crystal structures and, on the basis of this, developed the theory of atomic structure of the main minerals in the earth's crust, as well as of many other materials essential for national economy".

"Some 10-15 years ago, an analysis of every atomic structure took 3-4 years and could only be done by a specialist with extremely high qualifications."

"Recently Soviet scientists made an automatic diffractometer, an instrument which together with an electronic computer automates many highly intricate operations in the structural analysis of crystals. This instrument is now used in many laboratories throughout the world."

"How is information stored and passed on in a cell? What happens in an ageing organism and how do its tissues change? The answer to these and many other questions are being sought and found by biologists working alongside crystallographers".

"The application of structural analysis of crystals in studying the structure of biological objects—proteins, nucleic acids, vitamins, viruses, etc., literally caused a revolu-

tion in molecular biology. A knowledge of the atomic architecture of these giant molecules leads to an understanding of their biological functions. This, consequently, makes it possible to govern these processes."

"Soviet scientists have studied the structure of a number of natural compounds from amino acids (ordinary brick of which all proteins are made) to the giant molecules of viruses which contain millions of atoms. This type of research, which is being continued successfully, forms the border line between the organic and inorganic and brings scientists closer to the innermost secret of nature, that is, to decipher the essence of life."

"Among the recent achievements of Soviet researchers is an apparatus for analysis of heterogeneity of semi-conductor crystals. Semi-conductor crystals are opaque to visible light but are translucent to infra-red rays. This instrument is based on the use of infra-red rays. Like an electronic beam in a TV tube it runs along the crystal and registers on the instrument all it has seen. This method makes it possible to spot in semi-conductor crystals heterogeneities and micro-admixtures that cannot be traced by any other means."

What important crystals have Soviet scientists succeeded in synthesising recently?

"The task facing physicists and crystallographers is not only to probe and study the structure and properties of crystals but to create those required in technology. This is all the more important since the natural storehouses of crystals are already becoming exhausted. However, even they cannot meet the needs of modern technology in quantity or quality. At present more than 1,000 artificial crystals are made in different parts of the world. These possess properties unknown in nature. One of the latest

achievements of Soviet scientists was the production of artificial diamonds which are now put out on a commercial scale, and the production of borazon, the diamonds's closest rival in hardness."

"The creation of optical quantum generators ranks among the outstanding discoveries of recent times. A synthetic ruby, processed in the form of a rod, with a small addition of chromium oxide is used as the generator of light. This rod is illuminated by a powerful flash of gas discharge tube and immediately radiates concentrated energy in the form of a beam. At present ruby crystals are used to shoot a record capacity of light beams running into ten million kilowatts. So far this flash lasts only a few nanoseconds (1 nanosecond = $1/1,000,000,000$ th of a second)."

"The Institute of Crystallography produced the first samples of Yttrium aluminium garnet, another crystal used in quantum electronics. This crystal is easily energised. It can be used to make a quantum generator operating from an ordinary incandescent lamp."

"Crystals are also used in quantum generators to guide the light beams. One of these crystals is potassium dihydrophosphate which can easily replace the mechanical shutter of a camera. The optical shutter developed at our Institute can give exposures of less than a millionth of a second. This is $1/1,000$ th of the time required by the quickest mechanical shutter. I should also like to mention the apparatus developed at the Institute for the synthesis of ruby and sapphire crystals. The crystals are grown from the pulverised initial material in flames at a temperature of over $2,000^{\circ}$."

How do you visualise the future of crystallography?

"The development of virtually every branch of crystallography holds our vast prospects.

Here are some illustrations taken at random. Of great interest are the so-called electro-optical crystals produced by Soviet scientists. A superimposed electrical field, as the name implies, alters their optical properties. This can be accomplished at colossal speed allowing for several thousand millions of switch-ons and switch-offs a second. This principle can be employed to make new super-fast computers without electrical circuits. They will be replaced by beams of light controlled by the electro-optical crystals which do the switching on and off. It may be expected that new types of TV sets will appear on the basis of these electro-optical crystals. The image in these TV sets will be formed by means of electro-optical crystals instead of electronic tubes."

"Finally (this idea has already been suggested) these crystals may be used to make

lenses and objectives with variable focus distances which will be regulated by an electrical field."

"Another illustration is albumen crystals. The determination of their structure has already disclosed the essence of such important processes as the combining of oxygen and hemoglobin—an important phase in the process of respiration. A study of the albumen crystals of lysozyme made it possible to understand how this helps the organism and destroys harmful bacteria. A study of the crystal structure of such proteins as *pepsin*, *trypsin* and others, which is now carried out in a number of laboratories throughout the world, including the Soviet Union, will disclose the essence of digestion."

By Courtesy: Moscow News, 48, 1967,

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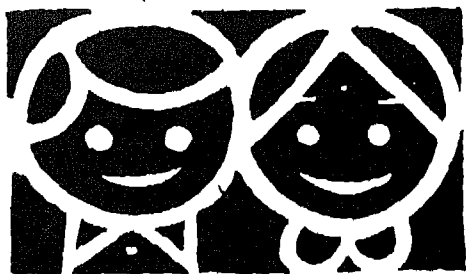
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Young Folks Corner

The Life and Work of Charles Darwin

DEEPAK YADAV

Pre-University Class, Govt. College for Men,
Chandigarh

PASCAL once remarked that the entire face of the world was changed by the shape of Cleopatra's nose. Almost two thousand years later the entire face of history was very nearly changed by the shape of yet another nose. In the fall of 1831 the 22 year old divinity student Charles Darwin, was to sail as an unpaid naturalist on His Majesty's Ship, the *Beagle*. But Captain Fitzroy, who

commanded the *Beagle*, hesitated to take Darwin along because he judged from the shape of Darwin's nose, that the young man had "neither the mentality nor the energy" to become a good scientist. Had Darwin never sailed on the *Beagle*, he would most likely have taken Holy Orders, and science would have lost one of its epoch making works—the story of the evolution of man. Fortunately, for the advancement of learning, however, Captain Fitzroy changed his mind about the shape of Darwin's nose and Darwin was allowed to sail on the *Beagle*. Captain Fitzroy and Darwin later became fast friends though their views differed widely. And thus the young theological student was launched upon a religious adventure of a new kind. He set out to explore and to interpret the world of God as inscribed in the Bible of living things.

Darwin was born at Shrewsbury on the same day as Abraham Lincoln, Feb. 12, 1809—a coincidence which led one of his biographers to see him as "the emancipator of the human mind from the shackles of ignorance, just as Lincoln was the emancipator of the human body from the shackles of slavery." The year 1809 was lavish with its meteoric shower of geniuses. In that one year an entire basketfull of them was dropped into the lap of humanity—Darwin, Lincoln, Gladstone, Chopin, Poe, Tennyson, Oliver Wendell Holmes and Elizabeth Barrett Brown-ing, to mention only a few. Every one of these "superior children of the human race" contributed something towards the permanent beauty and nobility of the world—and the contribution of Darwin was not the least among them.

As a child, Darwin was gentle, meditative and acutely observant of his surroundings. Even when he was confronted with danger

-----Paper presented at a "Scientific Paper Reading contest" organised by the Department of Botany, University of Punjab, Chandigarh, in January, 1969. This paper won a prize.

he was able to pursue his observations in the midst of his fear. One day, absorbed as usual in his thoughts, he was walking through the fortifications of Shrewsbury and stepped absent-mindedly over a parapet. Suddenly he found himself falling through the air, to his death, as he believed. Yet his wits were alert. This was but another interesting experiment for a scientifically minded little fellow. Darwin said later—"The number of thoughts which passed through my head during this very short but sudden and wholly unexpected fall was astonishing—all of which seemed hardly compatible with what physiologists have stated about each thought requiring an appreciable amount of time."

Darwin loved to collect and study all sorts of pebbles, shells, coins, birds' eggs, flowers and insects. His father considered Charles a good for nothing loafer whose only mission in life was to mess up the house with his everlasting rubbish.

Darwin's father desired him to study medicine but it soon became evident that Charles was not cut out to be a doctor. And so he tried to turn him into a clergyman. As a youngster Charles had shown distinct religious tendencies. As he ran to school each morning after breakfast, he prayed fervently to the Lord to aid him in arriving before it was too late. But—and this was a point which his father overlooked—Darwin started so late for school that it was necessary to pray.

For three years then, Charles studied at Christ College, Cambridge. He considered these 3 years to be a waste of time—time wasted in drinking, merry-making and flirting. It was at this college, that he met the eminent scientist Professor Henslow, through whose recommendation he was allowed to sail as a naturalist on *H.M.S. Beagle*.

For five years the *H.M.S. Beagle* sailed

over the seas and Darwin was privileged to behold with his own eyes "the wonder of the world and the mysteries of its teeming life." With the precision of a scientist and the imagination of a poet he collected, observed and classified the scattered fragments of the Chinese puzzle of existence and tried to piece them together into a comprehensive and comprehensible design. After twenty years of laborious research, he determined that his vast accumulation of facts when examined impartially, pointed to but a single theory—the theory of evolution by natural selection still provides the central framework of ideas for all biological science and will inevitably continue to do so. The theory of evolution is without any doubt the most important generalization yet made in the field of biology, worthy to rank with the great generalizations of the physical sciences, such as the conservation and degradation of energy, the modern theory of the atom, or Newton's Laws of motion and theory of gravitation. Charles Darwin made a far greater contribution than any other single man towards establishing the theory of evolution; he may indeed with some justice be called the Newton of biology.

It is interesting to note that whatever Darwin did, he did with the aim of knowing more about this new theory of evolution. Even when he fell in love with and married his cousin Emma Wedgwood and settled down in the country side to raise a family of ten children, he was all the time endeavouring to discover if possible, "the secret of their true ancestry."

This theory of evolution may be summarised briefly as follows,—“In this world of ours there is an unlimited multiplication of living creatures. The food supply, however, is limited, so too is the available living space in the world. The result is a life and death competition between all living things, an ever-

lasting struggle for existence. Those that are best fitted to their environment are able to live and the rest are doomed to die. The evolutionists call this process "the survival of the fittest." But in the course of time the environment keeps changing—from sea to land, from valleys to mountains, from glacial periods to periods of warmer climate, and so on. During these changes it becomes necessary for the living creatures also to change or to evolve from one species to another, in order that they may survive under the new conditions. The process by which this evolution takes place is called natural selection—that is nature's selection of those characteristics which enable the species to survive, and her elimination of those characteristics which are no longer necessary for survival in the new environment."

This, in a nutshell, is the whole story of evolution.

The theory of evolution is not the only contribution of Charles Darwin to the scientific field. He contributed much to the field of botany too. Darwin did extensive work on insectivorous plants and published a book about them. This book now provides us with solid ground for our modern knowledge in this subject. He published numerous smaller works too. He wrote books on the fertilization in plants, and the special devices for cross-fertilization involving the evolution of different kinds of flowers on the same species. In 1897 he produced "The Variation of Animals and Plants under Domestication"—an enormous Compendium of the knowledge he had amassed in this field, as a basis for understanding variation in nature but which also proved of great value for the practice of plant breeding and for the general theory of selection.

The Voyage of the Beagle; The Origin of Species; The Ascent of man wrongly named the Descent of man; The Expression of the

Emotions in Man and Animals; Movement in plants—these are just a few of the other books he wrote.

Darwin is generally credited with the theory that men are descendants from monkeys. As a matter of fact, he never said anything of the sort. He believed that men and apes are both evolved from a common prehistoric ancestor that is now extinct. The ape, in other words, is not our forefather but our distant cousin.

Man according to Darwin is the highest form of animal life. He is superior to other living beings. Man is a rational creature. He is best adapted to his environments. With his ingenuity he has learnt much of nature's secrets and has now extended a hand far out into the space to learn more about this universe of ours.

Many people were drawn to Darwin like a magnet and he in turn was drawn to other people. He had great love in his heart for his fellow human beings. In his bluish eyes there was a perpetual twinkle of sympathetic understanding. Such was the kindly serenity of his face that strangers would come away from their first visit with tears of joy in their eyes. Even though Darwin expounded the theory of evolution, he himself was not an atheist but regarded himself rather as an agnostic. He was not very certain of his belief in God but he was quite certain of his belief in man.

Darwin died at the age of seventy-three and with his death departed one of the noblest men that ever lived on this world of ours. Darwin's death was the signal for a world wide chorus of denunciation. His enemies consigned his "unrepentant soul" to hell. But one old lady in England thought otherwise. "To be sure Darwin has proved there is no God," she said, "but God is so kind he will surely forgive him."

Young folks corner

Great Dutch Pioneer of Scientific Research

WILLEM HENDRIK KEESOM

Discoverer of superfluid

THE New Academy, so called in order to distinguish it from the 15th century convent which for more than three hundred and fifty years has been the principal building of Leiden University, was built round about 1860. It rose at the spot where, in 1807, one of Napoleon's supply ships exploded while carrying a cargo of gunpowder. The New Academy contained not only the laboratories for physics, anatomy, physiology and chemistry, but also a room housing the administrative centre of Holland's oldest, and at that time largest university.

In 1882, Heike Kamerlingh Onnes was appointed to the post of senior Professor and Director of the Physics Laboratory. Four years earlier, Hendrik Antoon Lorentz, who, like Kamerlingh Onnes, was born in 1853, had been appointed Professor of Theoretical Physics. Together with Pieter Zeeman, a pupil of Kamerlingh Onnes, and the physiologist Willem Einthoven, they formed the quarter of Nobel prize winners in the early 1920s, whose work in the building was to earn them world fame.

As the title of this book suggests, however, we are concerned here not with these men and their work—which forms the subject of other publications in this series—but

with W.H. Keesom, one of Kamerlingh Onnes' successors. The other was W.J. de Haas. Both earned an international reputation, and both worked in "the ruins", that building from which Kamerlingh Onnes had some time previously ousted the other occupants, and which had become the international centre for cryogenic research.

Kamerlingh Onnes' greatest achievement, made on 10th July, 1908, was the liquifying of helium. His most important discovery, made in 1911 during his experiments with liquid helium, was superconductivity—i.e., the disappearance of electrical resistance in a number of metals at certain very low temperatures. Until his resignation in 1923, he devoted himself to studying the nature and characteristics of this phenomenon, thereby discovering that the presence of magnetic fields or the passing of powerful currents brought about its cessation.

The nomination of a successor to Kamerlingh Onnes posed severe problems. The task of controlling both the scientific and organizational aspects of the work of the laboratory had become too much for one man. It was decided to appoint two men to fill the post, and two of Kamerlingh Onnes' former pupils were viewed as candidates. One of them was W.H. Keesom, who, as the retiring Director's principal assistant, had been concerned in the preparations which led to the liquifying of helium, and who for some time subsequently had held a professorship in physics at the College of Veterinary School in Utrecht.

Keesom assumed responsibility for the liquifying of gases with the aid of which low temperatures were obtained—e.g., chloromethane, ethylene, oxygen, nitrogen, hydrogen and helium, in that order, and also for research into helium, caloric properties, X-rays and thermometry.

The son of a farmer on the island of Textel,

he was a devout and active member of the Roman Catholic church. He was a hard worker, and combined astuteness with caution. Although reserved, he possessed a clear sense of humour. He taught physics to a number of his children: his son, P.H. Keesom, now holds a professorship in the United States of America.

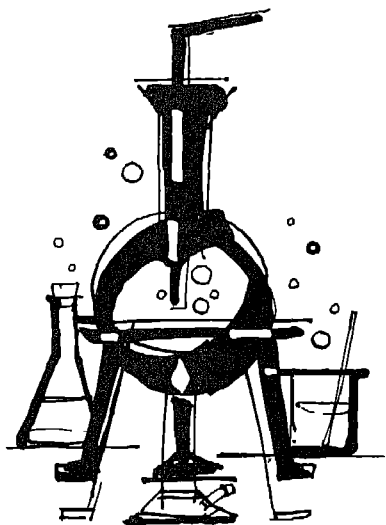
W.H. Keesom made two important discoveries concerning helium. The first was that, in contrast to other liquids, it displayed no tendency to crystallize at extremely low temperatures, but that this tendency was present at pressures of 25 atm. and above. His experiments involving high pressures not only served to produce solidified helium, but also to show that it remained in this state up to fairly high temperatures under increasing pressure. His most important discovery, however, was undoubtedly that of a second liquid phase, helium II, which occurs when helium is cooled to below 2.170 Kelvin. In this discovery, Keesom was assisted by two visiting scientists, Wolfke from Poland, and the German Clusius. Helium II, which is also known as superfluid or quantum fluid, possesses very remarkable properties. It displays very great thermal conductivity and can flow through a tube or circulate in a vessel without friction. Once in motion, a circular current of helium II does not come to rest of its own accord—a phenomenon highly reminiscent of electron superconductivity in metals. Only after the Second World War was a relatively satisfactory explanation found—with the aid of quantum mechanics—for the highly remarkable properties of these two “quantum fluids.”

Keesom and his assistants also carried out significant research into superconductivity, however, in deference to the division of tasks between himself and de Haas, he concentrated on the caloric properties of superconductors. In particular, he studied their specific heat, and discovered that normal conversion heat was replaced by a sudden rise in temperature at the point at which a material ceased to be superconductive. Together with the Swedish physicist Borelius, he embarked on a further series of investigations into another caloric property, viz. the thermoelectricity of metals and alloys.

Among Keesom's many other fields of research which are worthy of mention are his study of the crystalline structure of various solidified gases; his precision measurements concerning the behaviour of gases and gaseous mixtures, and isotope mixtures; and the application of those measurements of the science of precision thermometry. Alongside these were his efforts to influence the weather by scattering substances such as solidified carbon dioxide from aircraft. The results which he obtained were mediocre, however, methods similar to those which he used were later employed with success in low-rainfall areas of the world and he is regarded as one of the pioneers of artificial rainmaking.

Willem Hendrik Keesom, the Dutch scientist who discovered superfluidity, died in 1956 at the age of eighty.

Courtesy: Radio Nederland and National Museum for the History of Science at Leyden.



New Trends in Science Education

AT the school level science subjects are being taught in India as general science mostly from the theoretical point of view, with very little practical work. The Kothari Commission made a recommendation that science in schools should be taught as separate disciplines from class V, starting with Mathematics, Physics, and Biology, and Chemistry to be taken up from class VI. This recommendation has been accepted by

The NCERT Project on School Chemistry

PROFESSOR N. V. SUBBA RAO

Convenor ; NCERT Study Groups in Chemistry
Osmania University, Hyderabad

the Ministry of Education, Government of India and in pursuance of this, the National Council of Educational Research and Training (NCERT) has set up 18 Study Groups in different subjects under the stewardship of University Professors to develop curriculum and instructional material for the school level.

In Chemistry, five Study Groups were set up in September, 1966—one each at Chandigarh, Vallabh Vidyanagar, Poona, Madras and Hyderabad, with the Convenor's Group at Hyderabad. Each of these Study Groups consists of University and College teachers assisted by a few school teachers with a University Professor as Director. The Directors of Study Groups in Chemistry who met in October 1966, at Hyderabad, considered the then existing syllabus in the schools, the method of teaching and its limitations. It was generally felt that the teaching of chemistry as it is practised at present in schools is not satisfactory, as it emphasised mostly on memorising facts without doing any experi-

ment. The Directors felt that each lesson, as far as possible should start with a students' experiment followed by teacher-demonstration and only then the teacher should explain the theoretical principles. With this end in view, it was decided that while preparing the instructional material, a separate laboratory manual indicating the experiments to be done by the students, a text consisting of basic principles in Chemistry and a teacher's guide which gives instructions to the teacher in conducting the course, should be developed. The details of the teacher-demonstration should be included in the teacher's guide, so that the teacher arranges the demonstrations and keeps up the interest of the student in the theoretical portion related to the demonstration.

Curriculum

After considerable discussion, a draft outline of curriculum was prepared for a five-year course, which would reflect the attainment of a student in chemistry, leaving high school. This five-year course is further sub-divided into two levels. The lower level covering classes VI and VII and the higher classes VIII to X. The following eight topics, treated in an elementary way, have been included in the curriculum for classes VI and VII:

1. Chemistry and the material world
2. Structure of matter
3. Solutions
4. Chemical nomenclature and stoichiometry
5. Chemical reactions
6. Some familiar elements
7. Metals and alloys
8. Acids and bases

Syllabus for class VIII is considered as a link between lower and higher levels; the following topics are included:

1. Action of heat on substances
2. Action of electricity on substances
3. Structure of atom
4. Chemical bonding
5. Stoichiometry
6. Hydrogen, oxygen and water
7. Chemical families
8. Periodic classification

The materials for class IX and X cover the following topics:

1. Atomic structure
2. Chemical bonding
3. Energy changes in chemical reactions
4. Reaction rates
5. Chemical equilibrium
6. Chemistry of :—
magnesium and calcium,
aluminium and boron,
carbon and silicon,
nitrogen and phosphorus,
oxygen and sulphur
7. Manufacture of heavy chemicals—sulphuric and nitric acids, sodium carbonate and caustic soda.
8. Fertilizers
9. Glass, lime, mortar and cement
10. Acids and bases
11. Some properties of liquids and solutions
12. Electrochemical reactions
13. Chemistry of carbon compounds
14. Fuel gases
15. Metallurgy of copper, aluminium and iron
16. Sugar and fermentation industry
17. Oils—soap, hydrogenated oils; paints and varnishes
18. Natural and synthetic fibres; natural and synthetic rubbers
19. Petroleum refining, coal carbonisation (including coal tar distillation) and wood distillation

Some topics on the application of chemistry in industrial processes have been included at

this level as a considerable number of students passing the school examination are not likely to continue chemistry at the college level.

The materials developed for the lower level is mainly based on the atom-molecular model whereas the higher level is developed on the electronic structure (electron-ion model).

Publications

Books for classes VI and VII have been published and the material for class VIII is ready for publication in May, 1969. It is expected that the school chemistry books of classes IX & X will be available by the end of December, 1970.

The Study Groups also felt that some supplementary reading material should be made available to the students to help them widen the horizon of their knowledge, and appreciate the importance of chemistry in daily life. The publication of the supplementary reading material on the following topics will be undertaken very soon and will be made available during 1970.

1. Synthetic polymers
2. Proteins
3. Petroleum and petrochemicals
4. Shape and structure of molecules
5. Food and nutrition
6. Periodic classification
7. Chemicals from sea
8. Fertilizers
9. Fuels
10. Metals and alloys

Try-outs

The instruction material prepared for classes VI and VII has been tried in individual units in schools at Hyderabad, Madras and Gujarat (Vallabh Vidyanagar). Although it was not possible to conduct try-outs on the whole course, as instruction materials for this level, in Mathematics and Physics, are not available,

the few trials carried out on the students for classes VI and VII have shown that the material is well received by them, because of the student's laboratory work and the correlation of theory with practical work.

Laboratory Facilities and Teaching Aids

While devising the experiments and preparing the laboratory manual, care is taken to see that the experiments could be performed on flat desks in a classroom-cum-laboratory. It is not necessary to have a separate laboratory for doing this work. In a workshop organized during October, 1968, kits for student's work, as well as for demonstration by the teacher were developed and these are being further improved so as to reduce the cost of each student's kit for classes VI and VII, which works out approximately to Rs. 20/- and the consumable articles about Rs. 5/- per annum. The demonstration kits for teacher-demonstration for class VI works out to about Rs. 75/- each and class VII, Rs. 100/-. It is necessary to produce these kits on a large-scale when the cost will be further reduced. Further, there is scope for improvement of the kits in order to economise and make them more effective.

There are certain concepts which are difficult to demonstrate with experiments. For this purpose, it is necessary to have the curriculum supported by charts as well as filmstrips. The sketches for the charts were prepared, and the frames for the filmstrips drawn at the workshop have to be finalised in the next few months so that the large-scale production of charts and filmstrips can be undertaken as teaching aids to the instruction materials developed for classes VI and VII.

Orientation of Teachers

Since 1963, Summer Institutes for School Teachers have been conducted with a view to

orient the teachers to the recent trends in Chemical Education. During the period 1963-68, 61 Institutes in chemistry were held all over the country, covering over 2,200 teachers. During 1969 it is proposed to organize 18 institutes in chemistry for teachers from secondary schools/PUC colleges.

So far, the Summer Institutes for School teachers in chemistry have been following the CHEM-STUDY programme. It was felt by the NCSE Chemistry Panel that during 1969 a modified course based on the curriculum developed by the NCERT Study Groups may be tried at the Summer Institutes to be conducted at Hyderabad and Madras. A tentative programme of lectures and experimental work based on this curriculum was drafted for adoption at these summer institutes. At the recent Orientation Conference for the new Summer Institutes, held in January 1969 at Hyderabad, the Directors of Summer Institutes at Agra, Amravati and Jabalpur, have also agreed to follow this new course as a transition to the final adoption of

the curriculum and material developed by the NCERT Chemistry Study Groups in 1971. At the Summer Institutes of 1969, about two hundred teachers, will, therefore, be involved in this new programme.

Evaluation

One should realise that even with all these new instructional materials, developed, it will not be possible to have the real impact on the students, unless the mode of examinations is changed. The questions devised should be such as to develop the initiative and thinking in the students and should not be merely tests of memorisation. Both in the text and teacher's guide, questions have been framed and it is hoped that at the Summer Institutes, the teacher-participants themselves will develop material for tests to be conducted at the end of the course.

This new venture undertaken by the Study Groups with the assistance and active support of the NCERT is bound to make a big impact on the future teaching of Science in our schools.

Science Notes

Almost as fast as radioastronomy increases our understanding of the universe, it has discovered new mysteries of its own. Quasars—those incredibly powerful radio sources at great distances from the Earth, are one. Some quasars also emit light—so much light that no known physical process can explain it. One of the recent attempts to find out more about quasars has, instead of explaining them, discovered yet another mysterious group of objects and presented a new problem, the ‘ticking’ radio stars called pulsars. So puzzling are these that there was a short period when the scientists studying them thought they might be getting some sort of message from intelligent creatures in outer space.

Pulsars

TONY OSMAN

IT was Dr. Antony Hewish's group at the Mullard Radio Astronomy Laboratory, Cambridge, who decided that it would help in understanding the quasars if they were sure of their exact sizes. They knew they could find this out by studying the ‘radio-

twinkling” of the quasars. Radio stars, as seen on a radio telescope, twinkle in the same way as do ordinary stars, except that the effect is caused by uneven concentrations of charged particles in space, rather than unevenness in the air; the smaller the radio star, the more pronounced is the twinkling. The astronomers needed a special kind of radio telescope to look for the effect, so they had one built. It consisted of 2000 simple aerials connected to a receiver and it filled a four and half acre field. As it cost only £1000 it may well be the cheapest scientific instrument to make a major discovery in recent years. The connections could be altered so that the telescope “looked” at a series of different patches of the sky. As the Earth's rotation carried it round, it covered the entire sky, in strips, once a week.

This work started in the middle of 1967 and four hundred feet of paper recording the radio waves from space poured out each week. By a fortunate chance, all this paper was, looked through by a student, Miss Jocelyn Bell, who noticed something odd—a twinkling that occurred in the middle of the night. In theory, radio-twinkling should be at its maximum during the day. If the experi-

ment had been controlled by a computer, it would have ignored this unexpected result, because computers can, after all, look out only for what they are told to. One of the experimenters has said that discovering this unexpected twinkling was due to luck, in not using a computer; in truth, it was due to careful experimenting and observation.

Radio telescopes pick up a lot of interference, so the astronomers did not immediately take much notice of the new twinkle. However, it turned up half a dozen times in the same month at roughly the same place in the sky, so they decided to investigate further. Then the signals disappeared. Two months later, they reappeared. When they were carefully examined, they were found to be a regular succession of pulses, with a little more than a second between each. There was no possible explanation and nothing like it had ever been recorded before. The scientists cautiously decided to find out more before publishing their results.

They discovered that the source of the radio pulses was extremely small for a star—it could not be larger than half the size of the Earth—and that it was in our galaxy, a relatively near neighbour. It was at about this time that the astronomers seriously wondered if they were getting messages from outer space. Then they found some other pulsars five more at first. Another was reported by a Harvard group, followed by others found by a group in Sydney, Australia. Now the number of known pulsars is up to twenty, and will presumably rise because it is relatively easy to find something once you know what you are looking for. For a while, every issue of the scientific journal *Nature* seemed to contain something about pulsars—five per cent of everything printed in the journal in 1968 was on this topic.

The famous steerable-dish radio telescope at Jodrell Bank is not very useful for making surveys of the sky, but it is excellent for studying a radio star carefully once it has been found. The astronomers there looked at the first Cambridge pulsar and confirmed that the intensity was extremely variable. This is why the star had 'disappeared' for weeks at a time. Any particular part of the sky had been looked at for only four minutes in the original search, and if this period had coincided with a time when the star was faint, it was missed. The Jodrell Bank group also found that each regular radio beat had a fine structure of irregular beats within it. This added a further complexity for the theoreticians to explain, if they could.

But pulsars remain a mystery. The only known stars of the right size are the white dwarfs. These are extremely bright, but very difficult to see from Earth, because they are so small—about the size of the Earth or even less—and so distant. No pulsar has been found in the same position as any known white dwarf, but this is not an important objection, as it is thought that most of them are too small to have been mapped.

A white dwarf is a star that is near the end of its life. The size of a star is the result of a balance between the expansion caused by the energy of the star's "burning" and the contraction caused by gravity and as the star uses up fuel, the gravitational forces will diminish and the star expands. As it gets larger, it becomes less bright, and is called a red giant. Then, as the fuel starts to be useless for the fusion processes that heat a star, it collapses and becomes tiny, a white dwarf, glowing brightly because of the gravitational energy set free by the collapse. The trouble is that there is no known mechanism by which a white dwarf

could pulsate. Physicists have argued that it might quiver like a jelly—white dwarfs are liquid, but then they worked out that if it did quiver, it would become so unstable that it would collapse completely. Another possibility was that it was rotating, so that some radio source on it came round at intervals. Again, calculations ruled the theory out. If a dwarf star rotated quickly enough to give a flash every second or so, it would fall apart.

The next theory was that a pulsar was a neutron star. No neutron stars have ever been observed and it is not certain that they exist, but physicists have suggested that all stars must, in the end, decay to neutron stars. The theory is that, as the “burning” dies down and the white dwarf cools, the star will collapse further. Gravitational forces will be so powerful that they force the negatively charged electrons in the star’s atoms to combine with the positively charged protons in the atomic nucleus cancelling each other out. The star will then contain only neutrons, with no charge and it will be tiny—only about ten miles across—because the nucleus of an atom occupies very little space indeed. Its mass, of course, will hardly have been changed.

There is still a problem. How does a neutron star, if one exists, give off radio pulses? The current theory is that the neutron star, spins very rapidly. They are certainly dense enough to do so without falling apart. If they exist, the theory runs, they may be magnetised and have a charged atmosphere and the rotation may cause parts of the atmosphere, dragged round by the magnetism, to spin away so fast that they set up radio signals.

The latest results agree with this rather lengthy assemblage of theories, although they certainly do not confirm them. A pulsar

has been discovered in the Crab Nebula. This is a shining cloud among the stars and is all that is left of a brilliant explosion, the formation of a supernova, that was actually recorded by astronomers in A.D. 1054. The theory is that the formation of a supernova will leave a neutron star behind. Furthermore, a star formed as recently as a thousand year ago is likely to be spinning very quickly and the pulsar in the Crab Nebula is actually pulsating once every thirtieth of a second. It is the fastest-beating pulsar known.

The theory got some more encouragement towards the end of 1968, when it was found that this pulsar, at least, was not beating steadily but slowing down. It was slowing down at the rate of only one beat in 2000 over a period of one year; so that it needed very accurate observations to detect the slowing at all. A spinning star will slow down, so this result suggested spinning. Then, almost immediately, the Cambridge group discovered that their pulsars were slowing but this time by only one beat or so in ten million over the same period. As these stars must be older than the Crab Nebula supernova, the fact that they are spinning more slowly and slowing down less markedly, agrees with the suggestion that they are all spinning stars. The only stars that astronomers have thought of that could hold together if spinning rapidly are neutron stars, so these are now favourites as a way of explaining pulsars.

There is, however, no confirmation and the observations have recently added complications. The Australian group has noticed that many of the pulsars are grouped in pairs, near, but not on, the spiral arms of our galaxy, which the theory of neutron stars does not predict. And the astronomers at Jodrell Bank have discovered that there is a slow change in the beats of pulsars that

might be explained by a leisurely planetary motion; but they could think of nothing to explain the planetary motion. The discoveries about pulsars may come more slowly in the next few years than they have in the year and a half since the first one was found, but it will be a long while before everything about them is satisfactorily explained.

From *SPECTRUM*, 59, April, 1969

Humans With Identical Genes

The genetically identical frogs produced at Oxford University from the nuclei of fully differentiated intestine cells may be the first products of a new technique which biology and medicine could conceivably extend to man. If the nuclear transplant technique used by Dr. J.B. Gurdon and his colleagues at the Department of Zoology can be extended to mammals, then biology would be able to do such economically important things that it would be difficult to resist using it on a large scale. It would be possible to obtain an exact copy of any mammal at will—as many copies as required. This would be, no doubt, a great boon to those concerned with high quality animals. But the technique, once developed, might then be extended to humans, so that medical science would be able to duplicate anyone whose genetic qualities were considered desirable.

However, this possibility is not the aim or interest of the Oxford team. Their research, partly supported by the Medical Research Council, is concerned with how gene activity is regulated, a knowledge of which is fundamental in biology and medicine. The genetically identical frogs produced in their laboratories are simply a tool in this research.

From *SPECTRUM* 50, 1968

Frogs are used because their eggs are large and easy to manipulate, but there is no biological reason to prevent the technique being used on mammals.

The Oxford scientists are not concerned here in overcoming the technical difficulties, but to understand how genes are switched on and off by the cytoplasm of cells. It has been thought for a long time that all an individual's genetic information is contained in every cell, no matter how specialised that cell may be, and that genes are not lost in the processes of cell differentiation. To prove this, it is necessary to produce normal adult individuals from fully differentiated cells.

Eggs implanted with nuclei, from fully differentiated cells sometimes develop into complete adult frogs, but eggs which receive nuclei from endoderm cells (cells not yet fully differentiated which will lead to intestine cells) will grow into complete individuals much more frequently.

Developing embryos, where the initial fertilised egg gives rise to many different kinds of cells, of course provide ideal material for the study of gene activity. If every cell in the embryo has identical sets of genes, then gene activity must be suppressed or promoted in some way for cell differentiation to occur.

Embryologists concluded many years ago that regional differences in the cytoplasm of embryonic cells must exercise some control over the gene activity which leads to differentiation. And Dr. Gurdon and his colleagues, by transplanting the nucleus of one cell to the cytoplasm of another, have confirmed this conclusion.

For the Oxford experiments the South African Clawed frog, *Xenopus laevis*, is mostly used. A layer of cells (such as intestinal epithelium or endoderm cells) is taken from a piece of tadpole tissue and placed in a saline solution without calcium

ions but containing a substance called versene. The versene removes the calcium ions needed for cells to stick together in tissues, the cells then separate after about twenty minutes and can be kept for a few hours while waiting nuclear transplantation

Unfertilised eggs of the frog are then prepared to receive the transplants by killing their nuclei with ultraviolet radiation. The actual transplantation consists of sucking up a dissociated cell into a micropipette. This action breaks the cell membrane and much of the cytoplasm is lost, but a tiny amount remains. This is essential, because cell nuclei are irreparably damaged if exposed to any other environment than cell cytoplasm. The donor nucleus is then injected into the recipient egg.

By injecting donor cytoplasm into recipient eggs, it has been proved that the small amount which goes into the recipient egg with the transplanted nucleus has no effect on the subsequent activity of genes

Only a very small proportion of nuclear transplants from endoderm and fully differentiated intestine cells have actually given rise to fertile adult frogs, but 70 per cent of the transplants from the intestine cells of *Xenopus laevis* will support the development of normal muscle and nerve cells. The fact that fertile male and female frogs have grown from nuclear transplants shows, at least in some nuclei, that the genetic information is not altered or particularly lost during the processes of cell differentiation. Such a nucleus has been made to function by its host egg cytoplasm as if it were a normal fertilised nucleus.

Dr. Gurdon believes the nucleus from any type of differentiated cell could be used to initiate the growth of genetically identical organisms, but those cells, such as nerve cells, muscle cells and so on, which in the

complete organism do not divide for the purposes of growth and repair, do not usually or easily support normal development. The research with nerve cell nuclei on the one hand and intestine and endoderm cell nuclei on the other indicates this.

The cells, which in the adult animal do not divide, do not need, of course, to copy their genetic information; therefore they do not synthesise DNA in which this information is "written". But the cytoplasm of a fertilised egg, or that of cells which do divide, can turn on the synthesis of DNA again. Nuclei, for instance from brain and blood cells of adult frogs, when transplanted to fertilised eggs, will begin to synthesise DNA within an hour.

Nerve cells are used as nuclear transplants and they quickly switch on the synthesis of DNA, which is one of the things the team are studying.

Dr. Gurdon and his colleagues are now attempting to isolate components of cytoplasm—plasm which control genes and to understand how this control takes place. "Knowledge of the ways by which the activity of genes may be controlled," said Dr. Gurdon, "will be very important medically." But besides being of medical value, such control could have an even greater impact on society than the capability to produce numbers of genetically identical human beings. Not that this capability to duplicate organisms is undesirable in itself. The more control we have over living processes, the better. But it seems obvious, even at this stage, that the ways in which the more startling capabilities of the biological revolution are going to be applied will involve decisions of an importance greater than mankind has ever faced before.

EDWARD ASHPOLE

Sound and Pictures in a Single TV Signal

LONDON, November 18 — Television pictures and their sound tracks can now be transmitted as a single signal as a result of a new combining technique developed by the British Broadcasting Corporation.

Demonstrated in London recently, the new sound-in-vision technique claims to reduce transmission circuit requirements, achieve better quality sound reproduction, and give a better signal-to-noise ratio which is not affected by the distance to be covered.

It is equally suitable for transmission by land line, microwave link or satellite.

By exploiting pulse code modulation (PCM) — the latest technique for increasing the number of telecommunication channels carried on one circuit — BBC engineers have managed to squeeze the sound into the space between two of the 625 lines that make up the television picture. It is the first time that music has been transmitted by PCM.

The new system has already been successfully tested over the BBC's colour vision line between London and Scotland—a distance of nearly 400 miles. In service, the technique is expected to save the Corporation up to £75,000 a year in circuit rental time.

A Vast Untapped Source of Wealth

R. W. TINDALL

The exploits of American and Soviet astronauts have kept millions round the world enthralled.

So far, however, the public imagination

has not been captured to nearly the same extent by exploration of the vast unknown tracts here on earth—the sea and its bed, which covers four-fifths of the planet.

When the first astronauts return from the moon they are unlikely to announce a find of any commercial value.

Yet the sea holds resources of wealth which are yet barely tapped, despite the growth in size and sophistication of fishing fleets and the now familiar off-shore rigs and platforms exploiting the reserves of oil and natural gas buried in the sea-bed.

Some idea of the impact of the sea on our daily lives and the wealth it might one day be made to yield is given in a report just published in London.

Weather Forecasting

For example, large-scale movements of water masses with differing temperatures and salinities lead to the transfer of heat from one part of the ocean to another and so affect the weather through reaction with the air above. "It seems probable that the key to an improvement in our ability to forecast the weather may lie in a closer understanding of these air-sea interactions," says the report.

"The movement of sea water also affects the supply of inorganic nutrients essential for plankton growth and may in consequence be crucial in determining the basic productivity of fish stocks"

In addition to their salt content, the seas of the world also contain many rare elements, some of which are of potential economic value, so research into the chemistry of the ocean may also lead to direct benefit for mankind.

The report itself comes from a working party set up by the British Government to carry out an inventory of research into Go

vernment-backed marine science and technology and to suggest ways by which it might be better co-ordinated and improved.

Farming Fish

The British Government, which is spending something like £13,500,000 a year on this research, has accepted the group's report and says that its proposals for further spending will be considered in relation to other public needs.

But, perhaps, the report's main interest lies not so much in its recommendations as in the glimpse it has given of the many lines of research which are being pursued in Britain, at least.

The sea's most readily accessible commodity is, of course, its fish; but scientists are now far advanced in the art of rearing and fattening fish and shellfish in controlled areas—such as can often be provided by using the heated water released by coastal power stations—so that they can be "farmed" when ready, rather like any land crop.

The warmth emitted by power stations on the coast could also be used to cultivate species of high commercial value, such as clams, crabs and oysters, and the working party foresees export possibilities for Britain in the additional production of fish in these ways.

Hiding the Lobster

The fish and shellfish now caught represent only a small fraction of the biological resources of the oceans and here again it may be possible for man to modify the natural environment, so that the populations of desired species of fish increase rapidly.

Reducing the number of predators and increasing the food supply for the fish are possibilities being explored in several countries. The report even mentions the idea of

introducing into the sea artificial hiding places for lobsters.

Any increase in natural cover will have some effect on the number of lobsters in an area. What the scientists are now trying to find out is which kind of hiding place the lobster prefers!

The North Sea is now the field for intensive exploration for oil and natural gas, with many rich strikes already made.

But Britain has a share of the Continental Shelf—the gradual sloping area of the sea-bed around the coastline—which is something like four times the size of her island landmass, and the report points out that promising sedimentary deposits are known to occur elsewhere; in the Irish Sea, the western approaches to the English Channel and north-west of the Outer Hebrides, for example.

The report emphasises the need for a geological and geophysical survey of the whole of the United Kingdom Continental Shelf so that any important mineral resources do not escape undetected.

Sand and Gravel

For Britain, second in importance only to North Sea gas are the deposits of sand and gravel around her shores. Some 7,000,000 tons a year are now abstracted from coastal deposits—about 20 per cent of total production—but with demand rising and land increasing in price, the sea as a source of this vital building material is likely to become more and more important.

But finding the best and most economical methods of exploiting the deposits is only part of the story. For the scientists it means research into other aspects of the problem.

What does the removal of large quantities of sand and gravel mean when it comes to

preventing the erosion of the coast? How does it affect the shallow water fisheries and the nursery grounds for flat fish as it changes the topography of the sea bottom?

It is questions like these that scientists in a variety of disciplines are trying to answer. The report gives a comprehensive picture of men at work—on fisheries, mineral resources, coastal protection, the dangers of pollution from oil and industrial waste.

The sea is still full of mystery. And the search for answers may prove just as exciting as the quest in space.

Sound Waves can Help Heal Wounds

A TEAM of British biologists and physicists have found that sound waves can help recovery from injury.

They have increased the rate of healing of a wound by treating the knitting tissue with pulses of low-energy ultrasonic sound. An experimental wound was made in a rabbit's ear and an area of tissue one centimetre across removed. The wound was then treated with pulses of ultra sound over 15-minute periods three times a week. The

new tissue repairing the damage grew for faster than that in untreated wounds.

The reason for the speed-up in healing is not yet known. The two well-known physical effects of ultrasonic sound—the production of heat and cavitation, or the formation of bubbles—are certainly not involved. What may be going on is what the scientists call "streaming". The sound may be speeding up the processes inside the cells, including the "transport" of materials for building new ones. Later research goes some way to confirming this.

Ultrasonic sound is already used in medicine, mostly to provide a picture of internal organs. Different kinds of tissues absorb and reflect sounds in different amounts. The resulting echoes can be shown on film or a television-type screen, to build up a picture to detect, for example, pregnancy. If ultrasonic sound also has healing possibilities it may prove an important medical tool—for it can be localised, it is painless, and there are no side-effects.

The research work, by a team in the anatomy department at Guy's Hospital, London, forms part of an exhibit on ultrasonics at the Physics Exhibition in London (March 10 to 13).

Courtesy: British Information Service



Science and Science Teaching Project: NCERT/UNESCO

Several States of India are showing interest in the materials prepared by this Department for the middle school. The Department participated in several activities like Summer Institutes, seminars and working groups organised by Departments of Education in the States.

1. Gujarat

The revised syllabus of the Gujarat State was discussed at a meeting arranged by the State Department of Education. The discussion was with a view to bringing the syllabus in line with the middle school syllabus of science developed by the NCERT. The State Directorate has agreed to try out the first year's material at three centres in elected schools under the guidance of Extension

Service Centres of the Colleges of Education at Baroda, Ahmedabad and Porbandur. The M.B. College of Education, Anand has translated the second year's text materials also into Gujarati and they are trying out these in 12 schools. In continuation of their last year's work

2. Summer Institute for Science Teachers, Manipur State

The Summer Institute for 42 participants was organised by the Manipur Education Directorate from May 6—31 on training the science teachers in the curricular materials developed by the NCERT. Subject specialists from the Department, Shri N.K. Sanyal (Chemistry), Shri S. Doraiswami and Shri G. Raju (Biology) and Shri K.J. Khurana (Physics) acted as resource personnel for this course. They were all assisted by Shri D.N. Aggarwal, Shri R.S. Kashyap and Shree Patnaik from the Regional College of Education, Bhubaneswar. Besides these specialists, three lecturers from the local D.M. College were also involved so that they could become the key personnel for any future training programme of the State. Shri Yama Singh of the Directorate of Education, Manipur, acted as the Director of the Summer Institute. The participants were given an over-all view of the content materials of the whole middle stage and a detailed content analysis of the first year's materials in each subject. They all did the necessary demonstration and classroom activities under the supervision of the resource persons. The translations of the textbooks in Manipuri language was initiated and it is hoped that with the help of local resource personnel the translation would be completed and the textbooks printed in time so that they could be tried in schools from next school year. A full set of physics and chemistry kits used in the Summer Institute were left behind to

be used as prototypes by the local Directorate in order to make copies of the same for use in their school.

3. Summer Institute for Method Masters of Training Schools

The Ramakrishna Vidyalaya Teachers College, Coimbatore organized a one-month Summer Institute for the Methods Masters of Training Schools to orient them with the approach and content of the new curricular materials developed by the NCERT. Before the start of the Summer Institute three members of the staff of Ramakrishna Vidyalaya Teacher's College were oriented in the Department of Science Education for a period of 4 days at Delhi.

Subsequently, subject specialists of the Department—Shri K.S. Bhandari and Shri Chottan Singh participated in the training programme which was held from the 12th of May to 13th of June. Two Unesco Experts Dr. A.A. Tamarin and Dr. Y.I. Naumov also participated in the Summer Institute. One set of kits and equipment developed in the Central Science Workshop was displayed and the use of them was explained by the subject specialists. It is hoped that the Institute will be able to duplicate the kits and make use of them in their future training programmes.

4. Summer Institute for Biology Teachers

A Summer Institute for Central School biology teachers was organized by the Regional College of Education, Ajmer, in May 1969 at which the curricular materials developed by the Department of Science Education for the middle schools were used. The resource personnel of the Regional College of Education, Ajmer earlier came to this Department for a period of four days for briefing and orientation. At the institute the biology teachers were made

familiar with the text materials and they were made to perform all the demonstration experiments and classroom activities.

5. Dr. M.C. Pant visited Bombay and discussed with the Education Officer, Bombay Corporation, the feasibility of introducing the project materials in the corporation schools. It was agreed that the Corporation would organize summer course for training teachers for which the resource personnel would be oriented by this Department at Delhi. A team of 2 participants attended the orientation seminar held in this Department in June 1969.

General Science Project: NCERT/UNICEF Project

An experimental edition of "Science is doing"—a draft textbook for class III was brought out in April and the corresponding practical manual and kit guide for class III was also printed in April. The purpose of these publications was to try them out in a typical classroom situation, test the language level, suitability of the activities and also to use them in the summer orientation course of participants from the State Institutes of Education. Earlier the textbook was tried out with the children of three English medium schools in the first fortnight of May. The feed back obtained is being used in finalizing the text.

Summer Orientation Course

Under the UNICEF assisted project, a four-week summer orientation course for representatives of the State Institutes for Education/State Institutes of Science Education was organized in the Department from June 2—28, 1969. The objective of this course was to train the key personnel at this institute for initiating the Unesco/Unicef programme in their states. This course was attended by 17 participants from the states

of Maharashtra, Kerala, Gujarat, Madras, Bihar, Rajasthan, Punjab, Uttar Pradesh, Madhya Pradesh, Assam and Bombay Municipal Corporation. The trainees were exposed to the Science Education programmes in India and abroad and also to a detailed analysis of curriculum materials developed for the primary stage by the NCERT. Dr B. D. Attreya of the Department was in charge of the programme and he was assisted by Miss. S. Mazumdar and Shri H. L. Sharma. Mr. A. W. Torrie, Unesco-Unicef Consultant, Prof. Robert Stollberg and Dr. James DeRose from the NSF acted as whole time resource persons. From the Department, other subject specialists like Dr. M. C. Pant, Shri N. K. Sanyal, Shri S. Doraiswami and Shri Rajendra Prasad and Shri K. J. Khurana participated in their respective spheres in the programme. The course was inaugurated by Dr. Bhide of the National Physical Laboratory, Delhi, who laid emphasis on the role of the process of science in science learning. The following special lectures were delivered by the respective persons:

1. Objectives of the General Science,
—Shri N. K. Sanyal
2. The World Seen in Elementary Science Education
—Mr. A. W. Torrie
3. Elementary Science Education in India
—Present position.
—Mr. V. N. Wanchoo
4. Elementary Science in India, NCERT Programme
—Dr. B. D. Attreya
5. Elementary Science in U.S.A.
—Dr. R. Stollberg and Dr. DeRose.
6. Elementary Education in U.K.
—A. W. Torrie
7. Elementary Education in England
—A. W. Torrie
8. Elementary Science Education in USSR
—Dr. V. M. Galushin
9. Learning in Children
—Dr. (Mrs) Murlidharan

10. New Trends in Elementary Science —Dr. Willard Jacobson

Besides these lectures, there were also other experts who came and spoke to the participants. Among them may be mentioned Dr. (Mrs) Marjorie Gardner of the Earth Science Curriculum Project; Dr. E. Burkman of the Intermediate Science Curriculum Study.

The trainees did all the practical work relating to elementary science and prepared improvised models and demonstration equipment using the tools in the classroom. They also developed an outline of training programme for two months for science methods masters of teacher training schools. All the publications relating to science in general and the project in particular were distributed to the trainees.

Dr. Meiners and his associates from NSF and NCSE demonstrated their mobile laboratory at the Department. The valedictory address was given by Dr. P. D. Shukla of the Ministry of Education and Youth Services.

National Science Talent Search Scheme

The examination for the National Science Talent Search Scheme for this year was held on the 5th January, 1969. As a result of the evaluation of the scripts, 1100 candidates were called for interview at five centres namely, Chandigarh, Delhi, Calcutta, Bangalore and Bombay. The interviews were held in the month of May and out of these selections were made in the last week of June. The number of scholars selected this year is 349, and 10 more were selected for higher studies in mathematics. Shri N. Padmanabhan of M.E.A. Higher Secondary School, Lodi Estate came first among the successful candidates and Km. Ranjana Paul of Queen Mary Higher Secondary School, Tees Hazari was

the first among the girl candidates and sixth in order of merit. A list of scholarship winners is published elsewhere in this journal.

Seventeen Summer Schools were held in different university centres at which 700 science talent scholarship holders were engaged in summer courses involving practical and research projects under the guidance of university professors and teachers. All these seventeen institutes were for the scholars at the undergraduate level. The postgraduate scholars were attached to important National Laboratories, Defence laboratories and similar institutions in order to be enriched by guidance in research programmes from active research workers in the field.

Study Groups

Chemistry: The manuscript for class VIII has been discussed and now finalised and is being prepared for the press.

Biology: The Biology Study Groups met at Chandigarh for 10 days in April and discussed the draft of the text material for classes VIII, IX and X. The materials are now being revised on the lines suggested by this conference.

Physics: The Physics Study Groups decided to have two variants of text materials. One variant would be developed jointly by Delhi, Calcutta and Dehradun groups and the others would be prepared by the Jaipur group. The textbook for class V first version has been sent to the press.

Mathematics: Handbook for teachers for classes I to V is in the press. The geometry textbook for the first year of the middle school is under print at Bangalore. The manuscripts for the other two textbooks are ready for printing. The teachers guides for the first part of geometry is under print at Calcutta. The teachers guides for the remaining two parts were discussed and finalised in a meeting at Bangalore from 16th to 30th June,

1969. Arithmetic-Algebra textbooks for the middle stage have been completed and cyclo-styled and the same are now being reviewed before sending them to the press.

Supplementary Readers

Three more manuscripts have been sent for printing.

1. Birds and bird watching.
2. Rocks unfold the past.
3. Story of Transport.

The book, "Discovery of Oceans" is under print.

Assistance to other Agencies

The Education officers of the T.V. unit met the Head of the Department and subject specialists of the Science Department in planning a programme of television lessons for the training of science teachers of Delhi schools.

Visitors

The following distinguished persons from different parts of the world visited the department and had occasion to go through the work of the department as well as the materials prepared here. Some of these visitors were presented with selected publication of the department.

1. Mr. F.A. Durozinmi—Etti, Permanent Secretary for Education, Govt. of Nigeria, Lagos.
2. Prof. M.G. Bhide, National Physical Laboratories.
3. Participants of National Integration Workshop organised by Deptt. of Field Services.
4. American Peace Corps Volunteers for Bihar.
5. Mr. Eteki Mbourous—President of

- General Conference of Unesco.
- 6 Mr Cook, Dr. King and Mr. Paul O' Connor from National Science Foundation.
 7. Dr. Wilson and Mr. Moore, Nuffield Project.
 8. Mr. David Bates, Nuffield Project, London.
 9. A delegation from Burma composed of D1. Nyi Nyi, Secretary Ministry of Education, Dr. Sam Myint, Director, Institute of Education; Mr. Thaung Tut, Assistant Director of Education; and Mr. U. Mya Nyon, Director, Institute of Animal Husbandry and Veterinary Sciences.
 10. Dr Wilson of British Council, Delhi and Mr. Chessman of CREDO, London.
 11. Prof. Arthur Capmpbell, Dr. Lippin Cott and D1. King from U.S.A

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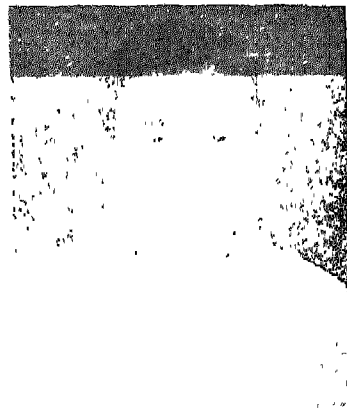
National Council of Educational Research and Training,

71/1 Najafgarh Road, New Delhi 15

NATIONAL SCIENCE TALENT SEARCH EXAMINATION
RESULT FOR 1989



Kum. Ranjana Paul 6th rank
Tis Hazari Quzen Mary Higher
Secondary School



Shri N. Padmanabhan 1st rank
Madras Education Association
Higher Secondary School, Lodi Estate

S.No	Rank No.	Roll No.	Name of the Candidate	Marks obtained	State
1.	1	3893	Sh. N. Padmanabhan,	172	Delhi
2	2	3850	Sh. Amitabha Mukherjee	171	Delhi
3.	2	12982	Sh. Samarendra Narayan Roy	171	W. Bengal
4	4	942	Sh. Ashok Mital	170	Delhi
5	4	26968	Sh. Salimuddin	170	Andhra Pradesh
6	6	78	Km. Ranjana Paul	169	Delhi
7	6	48054	Sh. Chinya Venkataram Ravishankar	169	Gujarat
8.	8	7983	Sh. Bishwajit Ghoshal	167	W. Bengal
9.	9	4020	Sh. Rahul Khullar	166	Delhi
10	10	3938	Sh. R. Raghavan Chari	165	Delhi
11.	11	26974	Sh. R. Murali	164	Andhra Pradesh
12	11	3481	Sh. Pratap Bhattacharya	164	W. Bengal
13	13	6825	Sh. Arjun Janah	163	Delhi
14	13	26966	Sh. K. Gopinathan	163	Andhra Pradesh
15.	15	263	Sh. Shiv Subramaniam Pillai	162	W. Bengal

S No	Rank No.	Roll No	Name of the Candidate	Marks obtained	State
16	15	11242	Sh. Devi Prasad Mitra	162	W. Bengal
17	15	12985	Sh. Probal Banerjee	162	W. Bengal
18	18	12979	Sh. Debashis Sarkar	161	W. Bengal
19	19	17419	Km. P.N. Pushpalatha	160	Delhi
20	19	13832	Sh. Gautam Radhakrishna Desiraju	160	Maharashtra
21	19	4935	Sh. S. Sridharan	160	Bihar
22	22	6581	Sh. Shankar Bhattacharyya	159	Maharashtra
23	23	6456	Sh. Tirthankar Banerjee	158	W. Bengal
24	23	12739	Sh. Manojit Sinha	158	Assam
25	25	37873	Sh. Partha Pratim Mitra	157	W. Bengal
26	25	14350	Sh. Arun Jagdish Manohar	157	W. Bengal
27	27	3799	Sh. Madhavan Arunkumar	155	Kerala
28	27	35638	Sh. Sunanda Dhar	155	Assam
29	29	1286	Sh. Arvinder Singh Sethi	154	Delhi
30	29	18911	Sh. Deb Das Karmakar	154	W. Bengal
31	29	12657	Km. Anuradha Rout	154	Orissa
32	32	1993	Sh. Pradip Kumar Dutta	153	W. Bengal
33	32	18554	Km. Leela Kar	153	Himachal Pradesh
34	34	4034	Sh. Dhrubo Kumar Sircar	151	Delhi
35	34	14458	Sh. Rakesh Tuli	151	Delhi
36	34	10531	Sh. Alok Tyagi	151	Madhya Pradesh
37	37	101	Sh. Kamesh Ramakrishna	150	Maharashtra
38	37	6819	Sh. Sugata Mitra	150	Delhi
39	37	6803	Sh. Deepak Naktia	150	Delhi
40	37	20751	Sh. Pradeep Goel	150	Delhi
41	37	33515	Sh. Alok Raj	150	Bihar
42	42	6831	Sh. Dipankar Mukherjee	149	Delhi
43	42	2956	Sh. Lele Shriram Prabhakar	149	Maharashtra
44	42	11497	Sh. Madhukar R. Patel	149	Gujarat
45	42	13009	Sh. Ravi Jaisinghani	149	W. Bengal
46	46	4976	Km. Godbole Rohini Madhusudan	148	Maharashtra

<i>S No.</i>	<i>Rank No</i>	<i>Roll No.</i>	<i>Name of the Candidate</i>	<i>Marks obtained</i>	<i>State</i>
47.	46	11636	Sh. Lokes Bhattacharyya	148	W. Bengal
48	46	1884	Km. Romi Narang	148	Delhi
49.	46	6826	Sh. Atul Aggarwal	148	Delhi
50.	46	1040	Sh. Snehamay Bandyopadhyay	148	W. Bengal
51.	51	3864	Km. Rita Jain	147	Delhi
52.	52	20764	Sh. Navin Govil	146	Delhi
53	52	13306	Sh. Babu Philip	146	Kerala
54.	52	13777	Sh. Murari Ashok Jagat	146	Maharashtra
55	52	6361	Sh. Santosh Iyer	146	W. Bengal
56.	52	3311	Sh. Anupam Khanna	146	Uttar Pradesh
57.	57	1885	Km. Pronoti Banerjee	145	Delhi
58.	57	21301	Sh. Sudip Sen	145	W. Bengal
59	57	33509	Sh. Gautam Ghosh	145	Bihar
60	60	17440	Sh. S. Ramesh	144	Delhi
61	60	1983	Km. Mithun Sil	144	W. Bengal
62.	60	5408	Sh. Kalyan Chatterjee	144	W. Bengal
63.	60	6459	Sh. Santanu Mukhopadhyay	144	W. Bengal
64.	60	12986	Sh. Shyamal Kanti Bhattacharya	144	W. Bengal
65.	60	4936	Sh. Percy T. Siganporia	144	Bihar
66.	66	17421	Km. A. Anandavalli	143	Delhi
67.	66	6830	Sh. Ranganath Sakalespur Visweswaraiya	143	Delhi
68.	66	31293	Sh. Navare Sharad Tribhuwandas	143	Maharashtra
69.	66	2390	Sh. Subir Sarkar	143	Maharashtra
70.	66	11434	Sh. Tejwani Manu Jamnadas	143	Gujarat
71.	66	12983	Sh. Anjan Bhattacharyya	143	W. Bengal
72	72	20619	Sh. Deepak Talwar	142	Delhi
73.	72	4022	Sh. Ambar Chatterjee	142	Delhi
74.	72	1004	Sh. Prajapati Trivedi	142	Delhi
75.	72	17450	Sh. N. Sampath Kumar	142	Delhi
76.	72	1859	Km. Anuradha Sanyal	142	Delhi
77.	72	1882	Km. Shailaja Rai	142	Delhi

<i>S No</i>	<i>Rank No</i>	<i>Roll No</i>	<i>Name of the Candidate</i>	<i>Marks obtained</i>	<i>State</i>
78	72	1474	Sh. Vijaya Kumari S.	142	Madras
79.	72	19041	Sh. Rama Krishna Ramaswamy	142	Madras
80	72	3804	Sh. Mani Jacob Kalliat	142	Kerala
81	72	11646	Sh. Tushar Basu	142	W Bengal
82	72	21302	Sh. Anjan Sircar	142	W Bengal
83	72	28422	Sh. Rama Kant Shukla	142	U P
84.	84	4008	Sh. Pronob Sen	141	Delhi
85	84	1517	Sh. Vijay Kumar	141	Delhi
86.	84	1300	Sh. Kapil Narain Bhalla	141	Delhi
87	84	45290	Sh. Bhaskar Venkataramany	141	A.P
88	84	2386	Sh. Suresh Mani	141	Maharashtra
89.	84	16422	Sh. Nazareth Jagdish	141	Gujarat
90	90	6987	Sh. Sanjiv Kumar Upadhyay	140	Delhi
91	90	16	Km. Krishna Bose	140	Delhi
92.	90	99	Sh. Rabindra Kumar Nair	140	Maharashtra
93.	90	13778	Sh. Kulkarni Narayan Janardan	140	Maharashtra
94.	90	4937	Sh. Akhouri Ratindra Nath	140	Bihar
95.	95	35487	Sh. N. Natarajan	139	Madras
96	95	13734	Sh. Shah Rajiv Rajaram	139	Maharashtra
97.	95	276	Sh. Palghat Krishnan Venkatramani	139	West Bengal
98.	95	7871	Sh. Deb Narayan Chakravarti	139	West Bengal
99	95	7056	Km. Sanghamitra Roy	139	West Bengal
100.	95	33520	Sh. Amarendra Bhattacharya	139	Bihar
101.	95	23412	Sh. Jeymohan Joseph	139	U P
102.	102	74	Miss Renana Jhabvala	138	Delhi
103.	102	22	Sh. Amitava Sen Gupta	138	Delhi
104.	102	1259	Sh. Atindam Banerjee	138	Delhi
105.	102	17417	Km. Ramaa Isvaran	138	Delhi
106.	102	3983	Km. Asha Rawal	138	Delhi
107.	102	19918	Sh. G.C.R. Subramaniam	138	Mysore
108.	102	11200	Sh. Pankaj Varma	138	Punjab

<i>S.No.</i>	<i>Rank No.</i>	<i>Roll No.</i>	<i>Name of the Candidate</i>	<i>Marks obtained</i>	<i>State</i>
109.	102	5310	Sh. Ashok Kumar Verma	138	M.P.
110.	102	20299	Sh. Lalit Mohan Patnaik	138	Orissa
111.	111	4012	Sh. Gupprit Singh Randhawa	137	Delhi
112.	111	31030	Sh. Dharam Vih Ahluwalia	137	Delhi
113.	111	17412	Sh. J. Bilachandran	137	Delhi
114.	111	26019	Sh. Sheel Aditya	137	Delhi
115.	111	17473	Sh. Cyrus Jehringir Umrigar	137	Maharashtra
116.	111	4932	Sh. Bhaskar Dasgupta	137	Bihar
117.	111	28278	Km. Bina Bhambhra,	137	Uttar Pradesh
118.	118	16599	Sh. Tara Chind Baporin	136	Delhi
119.	118	1869	Km. Mohini Duggal	136	Delhi
120.	118	1871	Km. Paranjit Kaur Luthra	136	Delhi
121.	118	20915	Km. C. Roshini Nayal	136	Delhi
122.	118	3161	Km. Meena Pottu	136	U.P.
123.	118	7192	Sh. Roy, P. George	136	Kerala
124.	118	44041	Sh. Khagesh Maheshwari	136	Rajasthan
125.	118	21903	Km. Shintarsi Choudhury	136	West Bengal
126.	118	30379	Km. Keya Bose	136	West Bengal
127.	118	5197	Sh. Debashish Baral	136	West Bengal
128.	118	11252	Sh. Sanjay Singh	136	Rajasthan
129.	118	25845	Sh. Uday Kant Choudhary	136	Bihar
130.	118	46431	Sh. Amitabh Misra	136	Bihar
131.	118	32921	Km. Anjali Nand Mathur	136	U.P.
132.	118	3319	Sh. Shailendra Mendiratta	136	U.P.
133.	133	6801	Sh. Anup Mathur	135	Delhi
134.	133	6805	Sh. Dev. Vrat Gupta	135	Delhi
135.	133	26001	Sh. Rakesh Sood	135	Delhi
136.	133	2678	Sh. Peruvambu Krishnan Ranganathan	135	Madras
137.	133	45289	Sh. Shankar Venkataramany	135	A.P.
138.	133	12040	Sh. Subramanian Krishnamurthy	135	Maharashtra
139.	133	21307	Sh. Madhu Anand	135	West Bengal

<i>S.No.</i>	<i>Rank No</i>	<i>Roll No</i>	<i>Name of the Candidate</i>	<i>Marks obtained</i>	<i>State</i>
140	140	3855	Sh Vinay Jain	134	Delhi
141	140	6877	Sh. Ashok Kumar Vashisht	134	Delhi
142	140	7576	Sh Ravinder Pal Singh Sandhu	134	Delhi
143	140	11243	Sh Devapriya Sen	134	Delhi
144	140	16573	Km. Sunanda Rao	134	Delhi
145	140	7024	Sh Umesh C Gaur	134	Delhi
146	140	1072	Sh Bhulchandra Lakshman Rao Tembe	134	Mysore
147	140	13740	Sh. Natu Sanjiv Vasant	134	Maharashtra
148	140	100	Sh. Sudhir Nikanth Pandit	134	Maharashtra
149	140	42181	Sh. Oza Ajay Kumar Tansukh Lal	134	Gujarat
150	140	7528	Sh. Mohinder Pratap Singh Pannu	134	M.P.
151	140	12953	Sh. Biplob Baran Bhattacharya	134	West Bengal
152	140	264	Sh Vijay Shankar Laghate	134	West Bengal
153	140	6379	Sh Gautam Mukherji	134	West Bengal
154	154	16601	Sh Chandra Mohan Sehgal	133	Delhi
155	154	16603	Sh Chandra Gupta	133	Delhi
156	154	17454	Sh S. Udaya Kumar	133	Delhi
157	154	29307	Sh Gaonkar, Sharad Govind	133	Maharashtra
158	154	29317	Sh. Medhekar Tushar Prabhakar	133	Maharashtra
159	154	21035	Sh. Amit Kumar Pathak	133	M.P.
160	154	7995	Sh Swapan Kumar Bhattacharjee	133	W. Bengal
161	154	7999	Sh. Dipak Biswas	133	W. Bengal
162	154	265	Sh Dipankar Mitra	133	W Bengal
163	154	16833	Sh Narendra Bhadra	133	W Bengal
164	154	21315	Sh. Suresh Hiremath	133	W. Bengal
165	154	7931	Sh. Biswajit Majumder	133	W. Bengal
166	154	20529	Sh Ashit Baran Sircar	133	Assam
167	154	33510	Sh Jayant Kumar	133	Bihar
168	168	1525	Sh Vikram Kumar Dikshit	132	Delhi
169	168	1276	Miss Jyotsna Pradhan	132	Delhi
170	168	26004	Sh. Sushil Kumar Jain	132	Delhi

<i>S.No.</i>	<i>Rank No</i>	<i>Roll No.</i>	<i>Name of the Candidate</i>	<i>Marks obtained</i>	<i>State</i>
171.	168	1874	Km Tripti Majumdar	132	Delhi
172.	168	37321	Sh. Satish Chander Khurana	132	Delhi
173.	168	29311	Sh. Anantharaman Sivaraman	132	Maharashtra
174.	168	13739	Sh. Gore Suresh Trimhak	132	Maharashtra
175.	168	21077	Sh. Vishwanath Krishnan	132	M.P.
176.	168	1039	Sh. Saritkumar Chakrabarti	132	West Bengal
177.	168	6366	Sh. Somnath Mukherji	132	West Bengal
178.	168	6395	Sh. Prabhakar Sastri Godivarti	132	West Bengal
179.	168	6419	Sh. Gautam Mukhopadhyay	132	West Bengal
180.	168	11241	Sh. Padmanabhan Srinagesh	132	Rajasthan
181.	168	30672	Sh. Sumir Kumar Bhattacharya	132	West Bengal
182.	168	9502	Sh. Akhilesh Pandey	132	U.P.
183.	183	946	Sh. Deepak Chopra	131	Delhi
184.	183	20627	Sh. Daksha Lohiya	131	Delhi
185.	183	72	Miss Pratima Sinha	131	Delhi
186.	183	1296	Sh. Ashwini Kumar Gupta	131	Delhi
187.	183	1299	Sh. Achal Kumar Jyoti	131	Delhi
188.	183	3914	Sh. R. Krishnan	131	Delhi
189.	183	3762	Sh. Gopalakrishnan, P.	131	Kerala
190.	183	3802	Sh. K. Narayanan Nair	131	Madras
191.	183	7729	Km. Madhumita Banerjee	131	West Bengal
192.	183	222	Sh. Amritasu Kumar Sihna	131	U.P.
193.	193	17428	Sh. P.S. Krishan Kumar	130	Delhi
194.	193	8004	Km. Jyoti Choudhry	130	Delhi
195.	193	21106	Sh. Ravi Swaminathan	130	M.P.
196.	193	8736	Sh. V. Krishnaaswamy	130	Madras
197.	193	32206	Sh. Michael Percival Neri	130	Madras
198.	193	9279	Sh. Natarajan, S	130	Madras
199.	193	42623	Sh. Arunachalam Ramakrishnan	130	Maharashtra
200.	193	7991	Shri Dhiman Kahali	130	West Bengal
201.	193	7870	Sh. Debasish Ghosh	130	West Bengal

<i>S.No</i>	<i>Rank No.</i>	<i>Roll No</i>	<i>Name of the Candidate</i>	<i>Marks obtained</i>	<i>State</i>
202.	193	18776	Miss Nabaneeta Mukhopadhyay	130	West Bengal
203.	193	24041	Sh. Sukanta Kishore Tripathy	130	Bihar
204.	204	954	Sh. Mahesh Kumar Uppal	129	Delhi
205.	204	14508	Sh. Rajeev Gautam	129	Delhi
206.	204	24989	Km. Hamsini Ramalingam	129	Madras
207.	204	1819	Mr. Gurjot Singh Malhi	129	Haryana
208.	204	2681	Sh. Krishnan Radhakrishnan	129	Madras
209.	204	40321	Km. K. Sree Devi	129	Mysore
210.	204	13735	Sh. Athale, Ravindra Anant	129	Maharashtra
211.	204	2847	Km. Jaya Das Gupta	129	West Bengal
212.	204	11639	Sh. Sujit Kumar Saha	129	West Bengal
213.	204	31960	Km. Gayatri Mandal	129	Rajasthan
214.	204	20443	Sh. Paresh Chandra Dutta	129	Bihar
215.	204	33507	Sh. Sujay Dey	129	Bihar
216.	204	3677	Sh. Devendra Singh Negi	129	U.P.
217.	204	41614	Sh. Akshaya Jain	129	U.P.
218.	218	20607	Sh. Gautam Sen	128	Delhi
219.	218	4038	Sh. V. Raja Gopal	128	Delhi
220.	218	17420	Miss P. K. Janani	128	Delhi
221.	218	70	Sh. Pradeep Kumar Deb	128	Delhi
222.	218	16574	Km. Tripti Kapoor	128	Delhi
223.	218	7002	Sh. Amar Prakash Gupta	128	Delhi
224.	218	12018	Sh. Joshi Niranjana Vasudeo	128	Maharashtra
225.	218	28346	Sh. Kanwaljit Singh	128	Maharashtra
226.	218	7907	Sh. Sampad Narayan Bhattacharya	128	West Bengal
227.	218	13058	Sh. Prajna Brata Sen	128	West Bengal
228.	218	6414	Km. Santwana Roy Chaudhury	128	West Bengal
229.	218	7921	Sh. Sumitendra Mazumdar	128	West Bengal
230.	218	11753	Sh. Ronald Gnanaraj Pillay	128	West Bengal
231.	218	9539	Miss Meena Mohindar	128	U.P.
232.	218	12784	Sh. Rajiv Kapoor	128	U.P.
233.	233	494	Sh. Ashok Kumar Bhardwaj	127	Delhi

<i>S.No</i>	<i>Rank No</i>	<i>Roll No.</i>	<i>Name of the Candidate</i>	<i>Marks obtained</i>	<i>State</i>
234.	233	4006	Sh. Harinder Sethi	127	Delhi
235.	233	26136	Sh. Raj Kumar Sharma	127	Delhi
236.	233	25	Sh. Rakesh Ohri	127	Delhi
237	233	17437	Sh. V. Sambasivan	127	Delhi
238.	233	46	Sh. Ajoy Kumar Deb	127	Delhi
239.	233	959	Sh. Suhit Ranjan Das	127	Delhi
240.	233	1872	Km. Anta Srivastava	127	Delhi
241	233	19872	Sh. Ragavendra Gadagkar	127	Mysore
242	233	4429	Km. Meena Padmanabhan	127	A P
243	233	13736	Sh. Akhave Shridhar Raghunandan	127	Maharashtra
244.	233	40177	Sh. Ajit Chaudhari	127	M P
245.	233	6355	Sh. B. Sathana Gopalan	127	W. Bengal
246.	233	10655	Sh. Sankar Das Samra	127	W Bengal
247.	247	20616	Sh. Raj Kumar Gupta	126	Delhi
248	247	4016	Sh. Arun Kumar Bhasin	126	Delhi
249	247	1289	Sh. Ajoy Roy	126	Delhi
250	247	3900	Sh. R. Vijaya Raghavan	126	Delhi
251	247	40102	Miss Sushma	126	Delhi
252	247	1866	Km. Neelam Pari Dadlani	126	Delhi
253	247	2748	Sh. K. Vaidyanathan	126	Madras
254.	247	35938	Sh. R. Ravi	126	Madras
255	247	8569	Sh. Vanbakkam Comandur Vijayaraghavan	126	Madras
256	247	21476	Sh. H. Thurumala Raya	126	Mysore
257.	247	2501	Sh. Nallari Ramana Pradeep Reddy	126	A. P.
258	247	22379	Sh. Nitin Vishnu Deoras	126	Maharashtra
259.	247	16419	Sh. Bhavsar Suketu Prafulchandra	126	Gujarat
260.	247	12748	Sh. Satya Kanta Saikia	126	Assam
261.	261	956	Sh. Anil Mahajan	125	Delhi
262.	261	3986	Sh. Suman Nayar	125	Delhi
263.	261	20621	Sh. Rajiv Jaluria	125	Delhi
264.	251	4037	Sh. Jayram Subrahmaniam	125	Delhi
265.	261	6812	Sh. Prasan Chowdiah	125	Delhi

<i>S No</i>	<i>Rank No.</i>	<i>Roll No</i>	<i>Name of the Candidate</i>	<i>Marks obtained</i>	<i>State</i>
266	261	42	Sh Arup Bhattacharya	125	Delhi
267.	261	1856	Km Purabi Bhaumik	125	Delhi
268	261	1883	Km Sharad Bala	125	Delhi
269	261	25445	Km Sushma Kitchlu	125	Delhi
270	261	36137	Sh Subrahmanyam Ravi	125	Delhi
271	261	1459	Sh Jayanth R Banavar	125	Madras
272	261	2513	Sh Jacob Mathew	125	Kerala
273	261	26973	Sh Srinivasan Sourirajan	125	A.P
274.	261	28067	Km Brinda Rajji	125	Maharashtra
275	261	29306	Sh Sharad Madhusudan Kelkar	125	Maharashtra
276	261	21049	Sh Govind Prasad Namdeo	125	M. P.
277	261	3485	Sh Paritosh Kumar Das	125	W. Bengal
278	261	42715	Sh Biswajit Bose	125	U.P.
279.	261	9580	Sh Arvind Kumar Awasthy	125	U P.
280	280	4047	Sh Partha Roy	124	Delhi
281	280	1263	Sh. Sayan Chatterjee	124	Delhi
282	280	15852	Sh Rajeev Jyoti	124	Delhi
283.	280	25432	Km Usha Menon	124	Delhi
284	280	2674	Sh V Mohan	124	Madras
285.	280	29312	Sh. Narayanaswamy Mahadev	124	Maharashtra
286	280	23571	Km Somdatta Sinha	124	West Bengal
287	280	16843	Sh Subroto Kundu	124	West Bengal
288.	280	11638	Sh Amit Basak	124	West Bengal
289.	280	21317	Sh Subrata Mandal	124	West Bengal
290.	280	35643	Sh. Kamal Chandra Neogi	124	Assam
291	280	9450	Sh. Kanvarjit Singh	124	U.P.
292.	280	3317	Sh Vijay Mohan Kohli	124	U.P
923	293	73	Miss Madhu Verma	123	Delhi
294	293	17186	Sh Balakrishnan Mani Vannan	123	Madras
295.	293	1457	Sh. Anand, K S.	123	Madras
296	293	13311	Sh Rama Krishnan, M.	123	Kerala
297.	293	27006	Sh. Vudata Chandra Prakash	123	A.P.

<i>S.No.</i>	<i>Rank No.</i>	<i>Roll No.</i>	<i>Name of the Candidate</i>	<i>Marks obtained</i>	<i>State</i>
298.	293	9902	Sh. Muralidharan	123	A.P.
299.	293	6118	Sh. Paranjape Ramesh Shivaram	123	Maharashtra
300.	293	12058	Sh. Vaz Francis Joseph Cyril	123	Maharashtra
301.	293	21918	Sh. Sree Bidyut Kumar Dutta	123	West Bengal
302.	293	23575	Sh. Bijayendra Nath Palit	123	West Bengal
303.	293	16862	Sh. Debobrata Acharya	123	West Bengal
304.	293	21316	Md. Nooruddin Ahmed	123	W. Bengal
305.	293	29372	Km. Rita Mohan	123	West Bengal
306.	293	12961	Sh. Sujit Kumar Deb	123	West Bengal
307.	293	41413	Km. Najma Usmani	123	U.P.
308.	293	28423	Sh. Krishna Mohan	123	U.P.
309.	293	5324	Sh. Ambrish Kumar Kush	123	U.P.
310.	310	18132	Sh. Niloy Kumar Dutta	122	Delhi
311.	310	21745	Sh. Ranju Singh Baxi	122	Delhi
312.	310	1012	Sh. Seshadri Harihar	122	Delhi
313.	310	1272	Sh. Pawan Towathia	122	Delhi
314.	310	8005	Km. Ram Venkatakrishnan	122	Delhi
315.	310	25433	Km. Neelam Kashive	122	Delhi
316.	310	2673	Sh. R. Gopalan	122	Madras
317.	310	2703	Sh. R. Sridharan	122	Madras
318.	310	1472	Km. Radha, S.	122	Madras
319.	310	9378	Sh. C. Narayana Sastry	122	Madras
320.	310	13249	Sh. P.S. Anand	122	Kerala
321.	310	45567	Sh. Suresh Srinivasan	122	Kerala
322.	310	33983	Sh. Talaprolu Gouri Sankara Babu	122	A.P.
323.	310	11341	Sh. Bharu Lal Chaudhri	122	Rajasthan
324.	310	32050	Sh. Rajiva Bapna	122	Rajasthan
325.	310	6582	Sh. Paramjit Singh Grewal	122	Maharashtra
326.	310	268	Sh. Arun Prabhakar Mohile	122	West Bengal
327.	310	274	Sh. Prodip Banerjee	122	West Bengal

<i>S No</i>	<i>Rank No.</i>	<i>Roll No</i>	<i>Name of the Candidate</i>	<i>Marks obtained</i>	<i>State</i>
328	310	6333	Km. Indrani Bose	122	West Bengal
329.	310	1689	Sh. Mahadev Banerjee	122	Bihar
330.	310	9578	Sh. Mukul Sahgal	122	U P
331	331	37361	Km. Praveen Kaur	121	Delhi
332.	331	3852	Sh. Shashikant Sathaye	121	Delhi
333.	331	3871	Sh. Riju Bowry	121	Delhi
334	331	21594	Sh. Kapil Dev Gupta	121	Delhi
335.	331	944	Sh. Rakesh Agarwala	121	Delhi
336.	331	3937	Sh. B. Purniah	121	Delhi
337.	331	7585	Sh. Returi Arun Kumar Rao	121	U P
338	331	13253	Sh. A. Rajaram	121	Kerala
339	331	39353	Sh. Chandrakant Shridhar Panse	121	Maharashtra
340	331	19359	Km. Manimala Deb	121	Maharashtra
341.	331	22351	Sh. Roy Sitendu	121	Maharashtra
342	331	16427	Sh. Shah Bhadrash Kantilal	121	Gujarat
343	331	38978	Sh. Suresh Joshi	121	M.P.
344	331	40181	Sh. Devraj Singh	121	M.P.
345	331	37867	Sh. Bappaditya Deb	121	West Bengal
346.	331	11238	Sh. Amtabha Sen	121	Rajasthan
347.	331	13010	Sh. Rajan Jaisinghani	121	West Bengal
348.	331	16695	Sh. Gourang Namdeo Mulay	121	West Bengal
349.	331	22277	Sh. Subinoy Jana	121	West Bengal

The list of candidates eligible for scholarship for higher studies with Mathematics as the main subject.

1	2	3	4	5	6
1.	1	17052	Km. Indira Narayana Swamy	120	Kerala
2.	1	23354	Sh. Akhil Ranjan	120	U.P.
3.	3	6416	Sh. Arunava Guha	117	West Bengal
4.	4	41198	Sh. James G. Singh	116	Punjab
5.	5	17432	Sh. B. Gopal	115	Delhi
6.	6	1310	Sh. Deepak Khanna	113	U.P.
7.	7	20869	Sh. S.C. Shekhar	112	Delhi
8.	7	14057	Sh. Diwakar Nigam	112	U.P.
9.	9	26461	Sh. Dinesh Kumar Sharma	111	Rajasthan
10.	10	1262	Sh. Leslie Joseph	110	Delhi



R C. SHARMA

V.I BAULIN

Deptt of Science Education, NCERT

SS.61: Calculate the value of

$$a^{1007} + \frac{1}{a^{1007}}, \text{ if } a^2 + a + 1 = 0$$

SS.62: A quadrilateral ABCD is inscribed in a circle with radius R. If $AB =$

$AD + BC = 2R$, prove that the bisectors of the angles C and D of the quadrilateral intersect on AB.

SS.63: Prove that the orthocentre of a triangle is nearest to the shortest side.

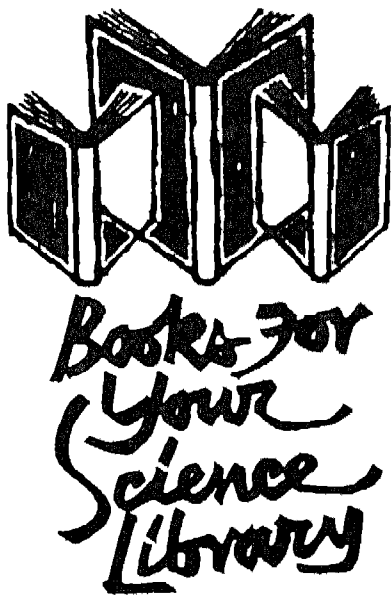
SS.64: (a) Two numbers a and b are such that a is smaller and b is greater than 1. If S is the sum of a and b and P is their product, prove that S and P differ by more than 1

(b) Hence show that if the product of two positive numbers is 1, their sum cannot be less than 2

(c) Using this result, or otherwise, prove that amongst all right angled triangles of equal area, the isocles triangle has the shortest hypotenuse.

SS.65: Construct the smallest equilateral triangle inscribed in a square. Construct also the largest equilateral triangle inscribed in a square.

Show, by simple means, that the triangles so constructed are indeed the smallest and largest possible. If the square is a unit-square, that is, the sides are equal to 1, calculate the lengths of the sides of the inscribed triangles.



WEAPONS OLD AND NEW: Mir Najabat Ali. National Council of Educational Research and Training, pp. 76. Rs. 2.25.

FROM STONE—FLINGING TO MOON-FINDING

—EVOLUTION OF WEAPONS—

Man is one of the weakest of creatures in the world, but he has been reigning the strongest among them all now and what is much more striking, has created quite a fascinating civilization, the like of which can not be claimed by any other living species. This astonishing achievement would not have been possible without various types of weapons he designed from time to time to protect himself against a world of animals or enemies. It is a wonder-work, starting from the crude stone-made hurtlings, and now fashioning

into horrifying space-raft missiles travelling incredible distances. In between float, the archery equipment, swords and spears, guns and grenades, firearms and rockets, tanks and torpedoes, mortars and submarines, radars and lasers, atom bombs and other members of the nuclear family. The subject matter itself is very interesting and Mr. Mir Najabat Ali, the author of the booklet, *Weapons Old and New* has made it most informative and instructive in his brief survey which is published for the benefit of pupils interested in the subject.

The outstanding quality of the work lies in the analytical approach, the scientific treatment and the research base it has received from the author. For example, even the juniors know how man first discovered the use of fire by causing friction between two hard-surfaced objects. But Mr. Najabat Ali dives deeper and furtheren lightens, that man must have done so after he saw lightning striking a tree and starting of forest fire. Similarly, an easily understandable reasoning has been advanced to explain why underground shelters ensure better protection to human frames than any other devices during air raids. The background materials in the form of historical events and scientific investigations are lucid enough for following the descriptions of newly-invented weapons of the modern nuclear days. The booklet ends in a befitting discussion of the likely evil effects of space conquest and lunar landing on the future warfare. A vital question is raised whether these glorifying explorations will not lead to 'wars even more fierce than those we have known—wars extending even into the newly acquired dimension', for every scientific discovery, we have seen, has been used for the improvement of fighting techniques, we have to agree with the author that time alone can provide the answer.

Good sketches and pictures bustle all through to illustrate the narration. However, colour shades should have been used to make the reading matter much more attractive for the students. It may also be suggested that when handing out statistical data, care should be taken to present the same in their totality and not anything just at random. While quoting figures for the cost of the two world wars, the entire ones have been given for the First but in the case of the Second, only the loss of human lives for Britain is listed and not the total number of those killed and wounded!

These minor drawbacks, however, don't detract the utility of the work as a standard textbook for those opting out for Military Science in the secondary schools. For the rest, it will serve as an enlivening supplementary reader. The NCERT must be complimented for making such a handy and handsome publication available to students who stand exposed to sudden flare of demonic and destructive nuclear war any moment.

“EX MAJOR”

THE UNIVERSE: Prof. P.L. Bhatnagar, National Council of Educational Research and Training, New Delhi, 1967

Man has been interested in the starlit sky since ancient times. Some of the stellar constellations have legends associated with them and have also been likened with some of the common animals. Some of the individual stars have been given names after the great “Rishis” of the past. Some of the brighter stars were used by navigators in the past for guiding them on the high seas and

were assigned names by these navigators. Aldebaran, Algot and Altair are the examples of such stars which were assigned these names by the Arabs.

A great impetus to the study of stars and constellations was given by Galileo's invention of the optical telescope in 1609. With the naked eye one can observe only about 4000 stars from any position on a clear night. But with the help of the telescope and the photographic plate, it is possible to observe about one hundred thousand million stars in the local galaxy, known as the Milky Way. The power of observation has been enormously increased with the invention of the radiotelescope which can observe radiation sources at a distance of a few hundred million light-years.

Chapter I of the present book gives a general introduction to the subject and Chapter II describes the properties of radiation. The next two chapters describe the main tools used in astronomy, viz., the optical telescopes and the radio-telescope and their mountings as uses. These two chapters, especially the chapter on radio-telescopes are slightly technical. But there will be no difficulty in following the other chapters even if these two chapters are left out by those who are not interested in technical details of the methods of observation of the stars and the galaxies.

Chapter V describes the stars and constellations in the Milky Way, i.e., our own galaxy. The chapter describes three coordinate systems used in astronomy. The descriptions are a little technical but one should be able to understand them by referring to the diagrams. This knowledge will be of use in locating the stars and constellations with the help of the charts given at the end of the book which are based on the equatorial system of coordinates.

The next three chapters are concerned with a description of the shape and size of the galaxies, their classification and distribution, and the occurrence of gas and dust in the interstellar space. Chapter IX gives a detailed discussion of the mass, constitution, spectrum, surface temperature and evolution of a star. The next two chapters describe the sun and its family of planets, satellites, asteroids and comets. The last chapter gives an account of the theories of the origin of the solar system.

The book thus gives a vast amount of latest information on different aspects of the Universe including the mysterious radiation sources the 'quasar;'. Although, according to the author, the book has been written primarily for the young reader, even grown up people will find it instructive and stimulating. The printing and reproductions are satisfactory.

An error seems to have inadvertently crept in on page 20, where the author says that "Radiation of frequencies even higher than these are associated with cosmic rays that come from all sides of the earth from extra-terrestrial sources". Actually cosmic rays are charged particles, mostly protons, and higher frequency radiations are produced in the upper atmosphere when these high energy charged particles interact with matter. Also on page 33 it is stated that "The theoretical limit of the resolution of a telescope is given by $L = 4.56/D$ seconds of arc, where the diameter D of the objective is measured in inches." It would have been better to indicate the wave-length of light which has been used here in calculating the limit of resolution.

R.N. RAI

SCHOOL SCIENCE

Vol. 7 No. 3

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In This Issue

VENUS

SCIENCE EDUCATION IN INDIA—
PROBLEMS AND SOLUTIONS

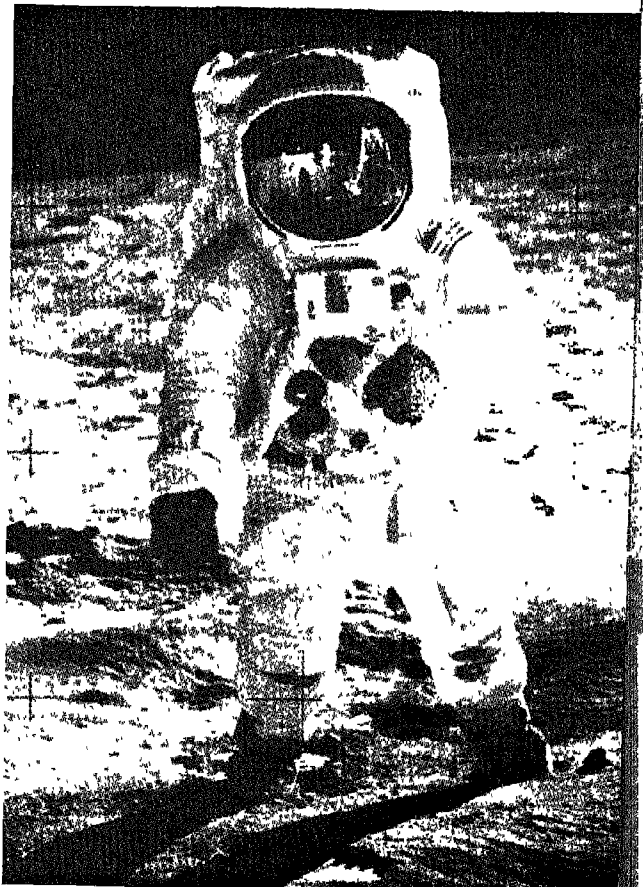
HUMAN PHYSIOLOGY AS A DISCIPLINE
IN MIDDLE SCHOOL BIOLOGY

DEVELOPMENT OF PRIMARY SCIENCE
EDUCATION AT NCERT

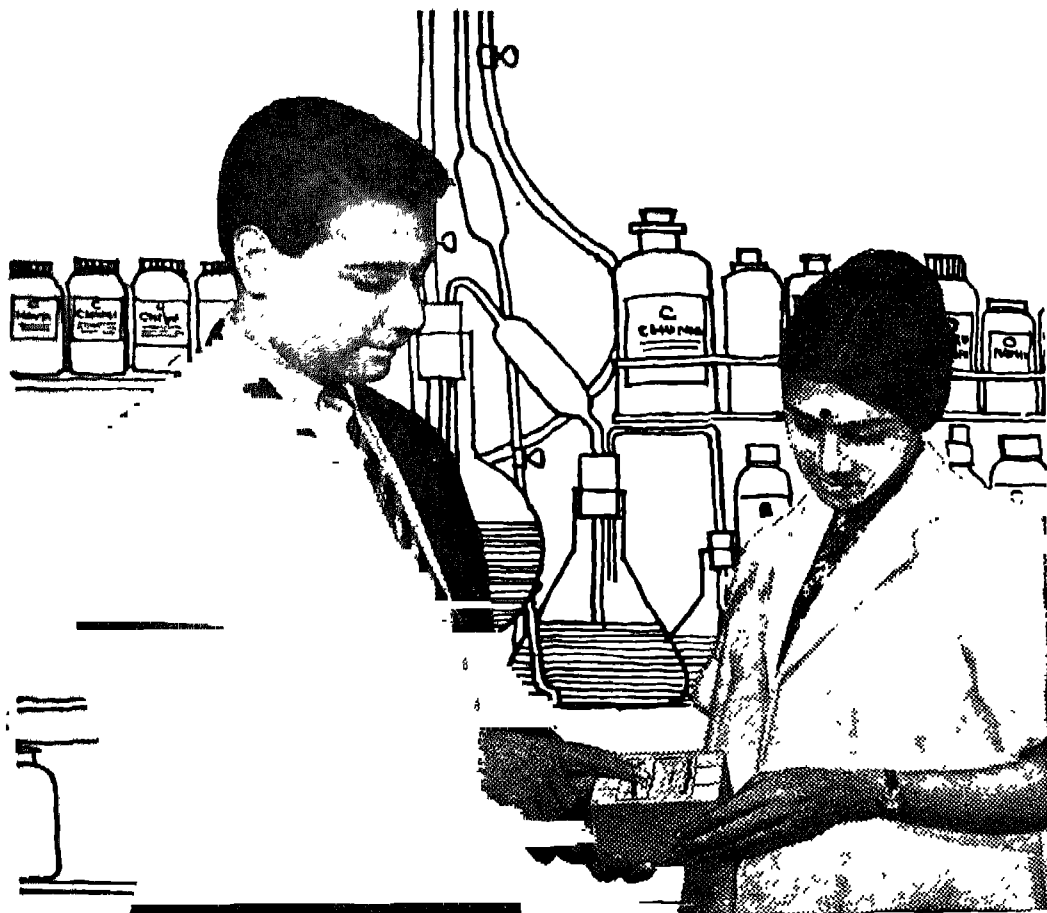
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CONTENTS

Venus	R. N. Rai	171
Science Education in India —Problems and Solutions	N. K. Sanyal	177
Human Physiology as a Discipline in the Middle School Biology	S. Doraiswami V. I. Galakhov	181
The Development of Primary Science Education at NCERT	B. D. Atreya A. W. Torrie	187
Science Education and Investigative Projects	Om Saraswat	199
The Shipworm A Timber Destroyer par excellence	N. Balakrishnan Nair	204
India's Success with Dwarf Wheats	M. S. Swaminathan	208
Study of Surfaces-II Effects related to Surface Tension	L. D. Ahuja	217
<i>Science Abroad</i>		
Elementary School Biology Revisited	John D. Cunningham	220
A Broad outlook for Plastics	J. H. Cowie	230
Promoting Teaching by Machine	Brynmor Jones	235
<i>Young Folks Corner</i>		
Nobel Award for Women of Genius—Mrs. Dorothy Crowfoot Hodgkin	W. Hargreaves	238
<i>New Trends in Science Education</i>		
Summer Institute in Mathematics Jadavpur University		241
<i>Science Notes</i>		
First Signs of Life and the Rh Factor		245
Tethered Mosquitoes used in Fight against Elephantiasis		247
<i>News and Notes</i>		249

Chief Editor
M. C. PANT

Associate Editor
S. DORAISWAMI

EDITORIAL

This issue of *School Science* opens with an article by R. N. Rai on the planet that was perhaps revered the most by mankind in earlier days—Venus. Beginning with an account of how Venus was worshipped by the Babylonians and Assyrians, the author goes on to trace the scientific researches conducted so far to probe the mysteries of this planet. He gives a full account of the various satellites sent up by man to observe Venus and records the facts discovered.

In *Science Education in India—Problems and Solutions*, N. K. Sanyal has dwelt on problems of science education arising from the increasing number of students. The author attempts to give practical solutions to these problems in order to make the study of science in India more effective. The article will perhaps be of special interest to teachers.

For teachers there are also two other particularly significant articles. In *Human Physiology as a Discipline in Middle School Biology*, S. Doraiswami and V. I. Galakhov outline a syllabus for introducing the study of human physiology in Class VIII and in *The Development of Primary Science Education at NCERT*, B. D. Atreya and A. W. Torrie discuss the need for effective science teaching at the primary level and trace the attempts made by NCERT to develop syllabi, text and teaching materials at this level.

Three articles will perhaps be of special interest to students. In *The Shipworm—A Timber Destroyer par excellence*, N. Balakrishnan Nair describes the life, habitat, habits and protective measures against a little known pest—the shipworm. The other two articles concern agriculture and physics. M. S. Swaminathan in *Dwarf Wheats* gives a detailed account of why and how dwarf wheats were developed in India, while L. D. Ahuja in the second instalment of *Surface Tension—II* goes deeper into the subject. This article is as lucidly written as was the first in the series. We expect the student of physics will benefit by it.

In the other regular features like *Science Abroad*, *Young Folks Corner*, *New Trends in Science Education* and *Science Notes* readers will find useful information regarding developments in the various areas of science and science education.

Finally, we who work on *School Science* would welcome comments and suggestions from readers regarding this journal. This will help us to serve our readers better.

Venus

R. N. RAI

National Institute of Science, New Delhi

VENUS is the brightest object in the sky after the sun and the moon. It has been recognised as a planet since ancient times. From the ziggurat at Ur were made careful observations of the motion of Venus. One cuneiform tablet gives observations of the appearances of Venus over a period of twenty-one years and dates back to about 1900 B.C. or even earlier. From such studies it was known even at that time that Venus makes five circlings in eight years, or, as we would say today, that five synodical years of Venus almost equal 2920 days¹. However, the theory that the Earth and the other planets go round the sun in almost circular orbits was not known and they had no idea of its period of revolution round the sun. But they knew that it alternately appears as a morning and an evening star (actually star is a misnomer but at that time the distinction between a star and a planet was not clear) in a period of 584 days, remaining a morning star for 292 days and an evening star for 292 days. But the Greeks were ignorant of this fact till the fifth century B.C. and

1. Synodic year is the time during which an inner planet makes one revolution more round the sun than the Earth and an outer planet makes one revolution less round the sun than the Earth.

then hailed it as a new discovery. This period, known as the synodic year, has been now accurately determined and has a value 583.92 days.

Since very early times, the Babylonians associated Venus with the goddess Ishtar, a deity who presided over both love and war. According to legend, as an evening star, Ishtar, the goddess of love, bestowed her favours on Akki, a humble irrigator, who was supposed to be responsible for rearing Sargon I (c. 2360 B.C.) who was found floating on the Euphrates in a basket of reeds sealed with pitch.

As the first dynasty of Babylon declined, the power of Assyria increased. But Venus continued to be worshipped as a goddess by the Assyrians and especially by the great kings Sennacherib (705-681 B.C.), Esarhaddon (681-668 B.C.) and Assurbanipal (668-626 B.C.). Venus and other planets continued to be associated with gods and goddesses by the Hindus and the Romans, but with the progress in the study of astronomy as a science, the association of the planets with the gods and goddesses became secondary in importance. There was a final break with the ancient beliefs with the Copernican theory of the heliocentric system.

Even before Copernicus, Heraclides of Pontus (388-315 B.C.) and Aristarchus of Samos (310-230 B.C.) had propounded the heliocentric system stating clearly that the apparent motion of the vaults of the heavens once in twenty-four hours was due to the rotation of the Earth on its axis. The Babylonian astronomer Seleucus of Seleucia who flourished a century later shared this belief. But the great majority of the ancient astronomers believed in the geocentric system. After Kepler had deduced, from the observations of Tycho Brahe, that the planets move round the sun in slightly elliptical orbits, it was possible to measure

the distances of the planets from the sun in terms of the distance of the earth from the sun. The maximum elongation of Venus from the sun is about 47° which shows that the distance of Venus is 0.723 times the astronomical unit, i.e., the distance of the Earth from the sun.

If the distance of one of the planets from the earth is known, it is possible to determine the distances of other planets from the sun by the application of Kepler's third law. On the earth the surveyor measures the distance of an unapproachable object by measuring the angle subtended by the base line of known length. This trigonometric method was applied to the measurement of planetary distances in the seventeenth and eighteenth centuries by observations on Mars and it first gave the correct order of magnitude of the value of the astronomical unit. The British astronomer Halley suggested the use of the transit of Venus across the disc of the sun for measuring A.U. Venus moves across the disc of sun periodically. The periods have alternatively the values 8 years and 235 years. The first transit after the acceptance of the heliocentric system was in the year 1631. Gassendi, a French philosopher, made preparations to observe it but was unsuccessful because Venus passed across the solar disc on December 6 when it was night time in France. The first transit was observed on December 4, 1639 by Jeremiah Horrocks, a young English clergyman. The transits which took place after 130 years in 1761 and 1769 on June 5 and June 3 respectively and again after 113 years in 1874 and 1882 on December 8 and December 6 respectively were used by astronomers to calculate the angle subtended by the equatorial radius of the earth on the sun. This angle is known as the solar parallax. Astronomers were much disappointed with the values obtained, as there was a large

scatter amongst them. Later other methods of determining the solar distance were developed. This value is now very accurately known from radar measurements and is found to be $149,597,892.3 \pm 1$ km.

The plane of the orbit of Venus is slightly inclined to the plane of the ecliptic, the value of the angle of inclination being $3^\circ 23' 39''$. If Venus happens to be in inferior conjunction, i.e., it lies between the sun and the Earth in a straight line, its position is to the north of the plane of the ecliptic from the beginning of December to the beginning of June and to the south of the plane of ecliptic from early June to early December. It, therefore, moves across the solar disc in December at the ascending node and in June at the descending node. The planet had the ascending transits in 1631, 1639, 1874, 1882 and will further have such transits in 2117 and 2125. It had the descending transits in 1761 and 1769 and will further have such transits in 2004 and 2012. As can be easily seen, it passes across the solar disc from south-west to north-east in December transits and from north-west to south-east in June transits. The present value of the longitude of the ascending node measured from the first point of Aries is about $76^\circ 14'$.

The orbit of Venus is only slightly elliptic, the eccentricity being less than that of any other planet. Its value is 0.0068. Its mean distance from the sun is 108.16×10^6 km and it goes round its orbit once in 224.70 days. Recent radar measurements show that the planet has a slow retrograde rotation, completing one rotation in 243.09 days. This is remarkably close to the 243.16-day period for which the spin would be in resonance with the relative orbital motions of the earth and Venus. In this resonance, Venus would make, on average, four axial rotations, as seen by an earth observer between successive

close approaches of the two planets. Thus Venus presents the same face to the earth at each inferior conjunction. The angle between the orbital plane and the equator of Venus is only 1.2° . Among the planets only Jupiter has a comparatively small inclination of 3° between orbital plane and equator, the corresponding value for all others being greater than 23° . The angle between the ecliptic and Venus's equator is 2.2° . In the case of the Earth, the sidereal day, i.e., the time the Earth takes to go round its axis is a few minutes less than the solar day. But in the case of Venus, on account of its retrograde rotation, the sidereal day is less than the solar day and is equal to 116.77 days.

If a planet has a satellite, it is possible to determine the mass of the planet by applying Kepler's laws. If M_p is the mass of the planet, M_{st} that of the satellite, a_{st} the semi-major axis of the satellite's orbit and T_{st} the period of revolution, then it can be shown that

$$\frac{a_{st}^3}{T_{st}^2 (M_p + M_{st})} = \frac{G}{4\pi^2},$$

where G is the universal constant of gravitation. If M_\odot , M_E , a_E and T_E are the corresponding quantities for the sun-Earth system, we have

$$\frac{a_E^3}{T_E^2 (M_\odot + M_E)} = \frac{G}{4\pi^2}$$

These two equations then give

$$\frac{a_E^3}{a_{st}^3} \cdot \frac{T_{st}^2}{T_E^2} = \frac{M_\odot + M_E}{M_p + M_{st}} \approx \frac{M_\odot}{M_p},$$

where the mass of the satellite has been neglected in comparison with that of the planet and the mass of the planet has been neglected in comparison with that of the sun. In this way the mass of the planet is obtained as a fraction of the solar mass. There are various difficulties in accurately

determining the two observational quantities in the case of a satellite. Also this method is not available for determining the mass of Venus which has no satellites.

Another method for determining the mass of a planet is to study the perturbation that it causes in the motion of other planets. The method is applicable to Venus which causes perturbations in the motion of Mercury. The mass of Venus obtained by this method expressed as a fraction of the solar mass ranged from $M_v/M_\odot = 407000$ to 409300. A very accurate value has now been obtained by observing the path of Mariner V. The result obtained for this ratio is 408522.6 ± 0.6 and the mass of Venus comes out to be 4.87×10^{24} kg.

The linear dimensions of a planet are measured by measuring the angle subtended by the diameter of the planet at the Earth. Half of this angle is the angular radius of the planet. If D is the distance between the planet and δ the angular radius, the actual radius R is given by

$$R = D \sin \delta = D \cdot \delta'' \sin 1'',$$

since δ is of the order of a few seconds. In the case of Venus, the difficulty arises from the fact that we can see only a part of the illuminated surface of the planet which limits the measurements to the direction of the line of cusps which is the arc of a great circle joining the ends of the horns in the crescent phase of the planet. This restriction can be avoided by measuring, at the time of a transit, the dark disc of the planet against the solar photosphere. Such measurements were attempted on a large scale during the transits of 1874 and 1882. The best value for the angular radius reduced to a distance of one astronomical unit is $8.75''$. This coupled with the value of the astronomical unit given above gives 6345.8 km for its radius which is now found to be too large. The value

obtained from earth-based radar measurements has been found to be 6053 km.

It is mainly through the voyages of the American satellite Mariner V and the U.S.S.R. satellite Venera 4 that much now is known about the temperature, pressure and constitution of the atmosphere of Venus. Not much was known about the atmosphere of Venus before 1931 when W. S. Adams and Th. Dunham, working at Mount Wilson Observatory, observed absorption bands in the near infrared spectrum of Venus. The band heads were situated at 7820.2, 7882.9 and 8688.7 Å. They were later identified with bands due to carbon dioxide. Later Kinper at the McDonald observatory detected very intense bands at 1.038, 1.050, 1.206, 1.220, 1.43 and 2.00 μ as well as several lines of less intensity. But no bands of molecular oxygen and water vapour were detected in the spectrum of Venus although bands due to neutral and ionized nitrogen were detected in 1953.

The satellites Mariner V and Venera 4 were equipped with apparatus to detect the presence of atomic hydrogen and oxygen. Both spacecrafts reported an increase in the concentration of hydrogen atoms in the upper atmosphere of Venus but neither spacecraft reported measurable quantities of oxygen atoms. According to Venera data the interplanetary hydrogen is 0.01 atoms per cubic centimetre. This increased to a value of 1000 atoms per cubic centimetre at an altitude of 1000 km from the planetary surface. But according to Mariner V, the hydrogen density at an altitude of 10,000 km from the planet's surface is much less than at comparable heights in the case of the earth. This shows that the temperature in the upper atmosphere of Venus is much lower than that in the upper atmosphere of the Earth.

The Venera 4 data indicate that 90 to

95% of the atmosphere of Venus is made up of carbon dioxide. The upper limit estimate for nitrogen is about 7% and the amount of oxygen about 1 per cent. The amount of neon appears to be more than that of oxygen but less than that of nitrogen. Venera 4 has also indicated a pressure of about 20 atmospheres on the surface of the planet. Thus the total amount of nitrogen and oxygen are comparable to their amounts on the earth. But the amount of neon seems to be much more than that on the earth. The amount of water vapour, according to Venera 4 lies between 0.1 and 0.7 per cent. The lower limit is supported by earth-based observations of the microwave emission from Venus. This would indicate that Venus is a dry planet and the amount of water on its surface is 10^{-4} times the amount on earth's surface. This amount is quite insufficient to explain the formation of the clouds which surround the planet.

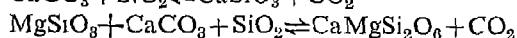
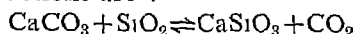
At a height of about 57 km the Venus is surrounded by clouds. The exact composition of these clouds is not known. Some people think that it is made of ice crystals. Others are of the view that it is composed of NH_4Cl particles which on falling down get decomposed into NH_3 and HCl which rise again to form NH_4Cl . Another view is that they are dust particles. It is remarkable that upto this height the fall in temperature is almost adiabatic but above this level, the fall in temperature is only about 1°K per km.

As is well known the increase in the refractive index of neutral gas is proportional to density. Knowing the variation in the density with altitude, it is possible to measure the temperature and pressure. The nearest approach of Mariner V to the surface of Venus was 4160 km. It could not therefore, measure the temperature and pressure of the atmosphere of the planet directly and adopted

this indirect method of determining its temperature and pressure. However, because of this high density of the atmosphere of Venus, the signals sent by the spacecraft were refracted or bent to such an extent, as they passed through the lower atmosphere of the planet, that they never reached the Earth. Hence even the indirect measurements of Mariner V do not give data for the lower levels reached by Venera 4 which soft landed on the surface of Venus. But the data for the intermediate heights given by Mariner V could be extrapolated to the surface of the planet. However, there is a discrepancy between the data for temperature and pressure given by the two spacecrafts. Venera 4 indicates a temperature of 544°K and a pressure of about 20 atmospheres at the surface of the planet. On the other hand the extrapolated data of Mariner V correspond to a temperature of 700°K and a pressure of about 68 atmospheres. Neither of the temperatures agree with the values of temperatures obtained on the basis of the microwave emission from Venus. These measurements give a surface temperature of approximately 650°K on the night side of the planet and approximately 750°K on the day side of the planet. More recent measurements indicate that the surface temperature is 700°K. The fall in temperature with height in the lower atmosphere is almost adiabatic (about 9°K per km). The minimum of the temperature occurs at a height of about 110 km from the surface and is about 200°K. Below and above this level the temperature increases. There is some uncertainty about the pressure at the surface but it is certainly much higher than 20 atmospheres and may be as high as 100 atmospheres.

The high temperature and the chemical composition of the atmosphere of the planet at a pressure greater than 20 atmospheres

suggest that the present atmosphere of Venus has been formed by chemical interaction with the lithosphere. The suggested reactions are :



Although the atmosphere of Venus is dry, the reactions should reach equilibrium conditions on account of the high temperature of the atmosphere and surface of Venus and should yield carbon dioxide pressure very close to that observed.

It is well known that the phase velocity of an electromagnetic wave increases in an ionized medium. Simultaneously it means an increase in the wavelength. It was observed that during its passage through the upper atmosphere of Venus, the radio signals from Mariner V underwent changes in phase and velocity which could be detected by instruments located on the Earth. The results obtained show that there is a peak density 5×10^5 electrons per cubic centimetre at an altitude of approximately 100 kilometres from the surface of the planet. This value of the electron density is comparable to the peak density in the ionosphere of the Earth during daytime although the height of the corresponding layer on the Earth is between 250 and 280 kilometres. Also the half width of the ionized layer on Venus is much less than on the Earth.

These data lead to the conclusion that carbon dioxide in the atmosphere of Venus is not much dissociated by the solar radiation. If dissociation had taken place, the lighter oxygen atoms would have diffused to higher regions where they would have been ionized by the solar ultraviolet radiation creating ions and electrons at high altitudes as is the case in the atmosphere of the Earth.

Much above the atmosphere of the Earth, there are belts of charged particles called the Van Allen belts. These belts consist of

protons and electrons which have been entrapped by the magnetic field of the Earth. There is no such belt surrounding Venus. This points to the absence of a magnetic field surrounding Venus. If there is such a field, it is certainly less than a hundredth, and most probably less than a thousandth, of the strength of Earth's magnetic field. Direct measuring instruments also indicate a similar value for the magnetic field of Venus.

Venus is similar to the Earth in its dimen-

sions and mass. Its distance from the sun is of the same order as the distance of the Earth from the sun. Presumably it was made of the same type of materials as the Earth. Yet the two planets seem to have evolved along two entirely different lines. This is very puzzling. Now that man has reached the moon and the results of the analysis of the rocks brought from there will be available to us in the near future, it may be possible to find an answer to this puzzle.

N C E R T

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Science Education in India—Problems and Solutions

N. K. SANYAL
Department of Science Education
NCERT, New Delhi

THE place of science as an integral part of general education at the school level has been recognized in this country for over two decades. Some form of science, as general science, environmental science, nature study or physiology has always been in our school curriculum up to the middle stage of schools, in all States. Yet the real quantum of knowledge gained has been little and in our schools, a *de-novo* start of teaching

science commences at the high school stage. With the rapid developments in science and the constant need of skilled personnel for a developing economy and the need to build a base for higher research in science a new approach to science education at the school level has become necessary. Our educationists, laymen and government are all alive to it and have given considerable thoughts to this.

Problems in Science Education

1. Numbers

It is natural that there is a tremendous increase in school population since independence as may be seen in Table 1

This brings the problems of finding adequate number of teachers, their training, physical facilities and supervision.

2. Content

The ever expanding boundaries of science doubles the content knowledge in ten years. More and more content force their entry into the school curriculum. The problem is to decide what should be taught at different levels of school and how deep

It is increasingly being realized that the emphasis has to be on the process of science rather than on the facts of science. Teaching of science has to start from the earliest stage

Table 1

YEAR	PRIMARY		MIDDLE			
	No. of Schools	Enrolment	No. of teachers	No. of schools	Enrolment	No. of teachers
1947	1.73 lakhs	141 lakhs	4.06 lakhs	—	20.4 lakhs	72,400
1963	366 „	415 „	8.26 lakhs	—	81.6 lakhs	420,800

Paper read before the Asian Seminar of the Chief School State Officers of U.S.A. at the NIE campus.

SECONDARY (Enrolment)

Year	General Course	Vocational Course	Total
1950-51	13.36 lakh	1.62 lakh	14.98 lakh
1960-61	31.39 „	4.22 „	35.81 „
1965-66	50.00 „	7.00 „	57.00 „

of school and continue as a compulsory subject throughout the school course.

This brings in the problem of adequate share of time in the whole curriculum.

3. Methodology

Closely connected with the vastness and complexity of the content is the method and approach to be adopted so that it is meaningful, interesting and useful to the child not only as a developing citizen but also to develop the foundations for deeper study for those who go ahead for college education.

4. Instructional Materials

Up-to-date textbooks must be developed on the lines of the objectives, contents and methodology. Adequate support has to be given to teachers through companion teachers' guides. Modern audio-visual aids like charts, filmstrips and films have to be developed in close integration of the contents. Preparation of all types of instructional materials is a huge task, more so when the regional languages are considered through which instruction at school level has to be done.

5. Structure of School

The structure of school in various states varies leading to a school final or higher secondary ranging from ten to twelve years. No single curriculum or course of study can be therefore recommended. Every State has to adapt from a certain basic model. This requires a lot of academic work at the State level.

The following table gives an idea of the structure of school in different states.

Table 2

I-IV, V-VIII, IX-XI PUC	3 years Degree
I-V, VI-VII, VIII-XI PUC	„
I-V, VI-VIII, IX-X PUC	„
I-V, VI-VIII, IX-XI	„
I-V, VI-VIII IX-X, XI-XII	2 years Degree.

6. Training of Teachers

The training of teachers is the pivot of any development programme. Not only they have to be initially proficient in content, but have to be constantly refreshed with new knowledge of subject matter and new approaches to teaching that are constantly developing.

7. Physical Facilities

Learning science at the school stage is by doing. For this adequate physical facilities and equipment are necessary.

Programmes for Solutions

Considering the above problems, rethinking on science education has brought some major national programmes for the improvements of science teaching in schools.

1. Curriculum Projects of D. S. E.

To provide leadership the Department of Science Education in NCERT was established in 1963 which has taken up the major task of developing curricular materials, syllabi, textbook, teacher guides, equipment, kits, supplementary reading materials and other audio visual materials.

The Department has already prepared syllabi, guidance materials and texts in general science for the primary stage. For the middle stage it has developed complete set of syllabi, texts, teacher guides and prototypes of equipment and kits for teaching physics, chemistry, biology and mathematics as separate subjects.

Work at the high secondary stage courses in above subjects as compulsory courses as in progress. These are all being done with assistance from UNICEF and UNESCO.

Since education is a state subject, the states are exposed to the materials developed and they are adapting these on an experimental basis for extensive use at a later date.

2. Study Groups

The NCERT established in 1966 'Study groups' established in 20 Universities to obtain expert services of the universities for identifying basic concepts of various science disciplines and present them in a logical way for building better understanding in students.

The Study Groups have completed an alternative variant of texts and guide books for the middle stage and are now engaged in the task of developing materials for the high school stage.

3. Panels for Text Books

While the above curriculum projects are engaged in long term plans, the NCERT established a number of text-book panels or editorial boards to develop better text books based on the current syllabi. These panels have developed text books in biology, physics, chemistry and general science. The biology books are used in over 600 schools as texts, while others are gradually being accepted by the States.

4. National Science Talent Search

To locate and nurture the gifted student

of science a national scheme was initiated in 1963 as a pilot and extended as a national scheme in 1964. Under this scheme each year 350 students are selected after quite a vigorous test and interview and financially assisted for higher studies up to the Ph. D. stage. Through follow up schemes of guidance in summer schools they are constantly nurtured.

5. Regional Colleges.

These colleges were developed in 1963 by the NCERT to provide for an integrated teaching of content and pedagogy for training teachers of science, technology, agriculture and commerce. These colleges are also centres for conducting an improved one year training programme for science teachers on the existing pattern, for inservice education and for research in education.

6. Summer Institutes

To keep science teachers abreast of knowledge in subjects and advances in methodology the NCERT in collaboration with UGC and NCSE has been organizing summer institutes in physics, chemistry, biology and mathematics at various University centres. Till 1968, 236 such institutes have exposed nearly 9,000 teachers in different subjects to modern developments in science and their teaching.

7. Crash Programme of Third Five Year Plan

- a) Provision of funds for equipment to secondary schools —Rs. 5.5 million made available to state Govts.
- b) Establishment of *State Institutes of Science* for providing an academic and technical arm to State Departments of Education. 13 such institutes have been established.
- c) Long term and short term training programmes for science teachers.

d) A nine-month content course at post-graduate level at Universities or State Institutes of Science for B. Sc. teacher to improve his academic competence. The other is four to ten weeks course to update the content knowledge of the existing teachers. The States have established these courses with financial assistance from the Centre.

8. *Project for Reorganisation and Expansion of Science Teaching throughout the School Stage.* (UNESCO/UNICEF assisted project)

This UNESCO-UNICEF Project aims at reorganising and expanding the teaching of science throughout the country with a view to develop scientific literacy and scientific attitude.

The main components of the project are:

- i) Development of new syllabi for science courses for the whole school stage and for teacher training programmes.
- ii) Development of instructional materials,

text books, laboratory manuals, teacher guides and preservice training materials.

- iii) Training of science educators and science teachers through short term orientation cum refresher courses.
- iv) Equipping key institutions and selected schools with necessary science and workshop equipment.
- v) Introducing revised syllabi and instructional materials in a phased manner in schools.

The role of NCERT is to develop the new syllabi and instructional materials, training of the key personnel in States, preparation of teacher training programmes and development of prototypes of equipment and kits related to the teaching materials. The materials already developed in the NCERT are going to be used on a pilot basis in 30 primary and 30 to 50 middle schools from the next school year in various States. So far one State is using these on a regular basis in all schools. Seven States have already agreed for the pilot project and discussions with other States are in progress.

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by

S. P. Ray Chaudhuri

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Aims at presenting an over-all view of the major areas in the subject without entering into specialized details required for advanced studies. The text is in simple English and all technical terms have been defined with clarity

Enquiries :

Business Manager, Publication Unit, National Council of Educational Research and Training, 71/1 Najafgarh Road, New Delhi 15

Human Physiology as a Discipline in the Middle School Biology

S. DORAISWAMI,

Department of Science Education,
National Council of Educational Research
and Training,
New Delhi

V.I. GALAKHOV,

UNESCO Expert,
Department of Science Education,
National Council of Educational Research
and Training,
New Delhi

THE schools in Delhi working under the Project for improving Science teaching initiated by the Department of Science Education of the NCERT with the assistance of the UNESCO experts have started this year that part of biology dealing with study of human organism, namely, human physiology. The study of Human Physiology as a separate discipline of the middle school biology course is new to the Indian schools. Hence, there is a need to familiarise teachers with the features of the course, its objectives, principles on which

the syllabus is based, its content, its link with other biological disciplines (botany, zoology and general biology) as well as the importance of the subject in the entire system of training of an individual and preparing him for independent life.

According to the recommendations of the UNESCO Planning Mission (1964), this course is included as the third section of school biology course, following botany and zoology. As this question is related to our topic, it is dealt with in detail here. Modern technological progress has resulted in a rapid development of biological sciences and the methods of research in the same. Accordingly, every new branch of these sciences emerges and acquires significance as an independent science. Thus several sciences have emerged namely bio-chemistry, bio-physics, bio-geo-chemistry, cybernetics, bionics, etc. The volume of biological knowledge is tremendous and it is increasing almost everyday. The important task of a school biology course is to sort out, from this huge mass of data, and discover those basic facts and concepts that every young man and woman should know at the time of finishing school.

There is also the problem of putting this knowledge in a comprehensive and concise form and at the same time at the level of modern achievements; and to arrange the material from simple to complex and in accordance with the age of the pupils and their ability to assimilate the materials taught.

At present, in a number of countries of the world including India, these problems in the field of biological education are attempted to be solved by teaching general science, or teaching biology as a complex science without dividing it into separate disciplines.

The approach to the study of biology

recommended by the UNESCO Planning Mission (1964) is based on the assumption that the structure of school biology course should be founded on such important didactic principles as systematisation and logic of the instructional materials while reserving its scientific aspect and comprehensibility. It is easier to develop a course in biology which takes into account these principles of teaching sections of biology as separate and individual disciplines.

Only a logical and sequential study of the specific sciences of plants, animals and human organisms will ensure the acquisition of firm scientific knowledge of the subjects which the pupil could apply later in his life.

Based on these facts regarding the treatment of biology of plants, biology of animals and biology of man as separate disciplines, these are included in the middle school biology in the following sequence:

Botany (Class VI)

Zoology (class VII)

Human Physiology (Class VIII)

At the end of class VII, is included a short course on 'Man and his Environment', which is suggested as a link between the middle school course and the high school biology.

The biology course for classes IX—XI is on General Biology dealing with topics of ecology, cell biology and genetics.

This system ensures a sequential accumulation of systematic knowledge on individual disciplines (Botany, Zoology and Human Physiology) in the middle school and their synthesis in the course of General Biology in the senior high school.

The sequence in which the subjects are introduced is determined by the comprehensibility of the instructional material arranged from the simple to the complex

and related to the age of the pupils and their development.

The course of Biology for classes VI-VIII is preceded by a subject of General Science in classes I-V. This course includes Units on water, air, soil, minerals, and gives an elementary idea of the life of plants, animals and man, his health and hygiene.

The course of biology in the middle schools begins with Botany, because at the age of 10 the world of plants is closer and understandable to the child.

The study of Zoology prepares the pupil for the specific study of Anatomy, Physiology and Hygiene of man and by way of comparison helps him to learn better, the qualitative differences in the structure and functions of man due to his capacity for work and his social environments.

In the senior high school, the biology course consists of General Biology which deals with three levels of biological organisation of living matter:

The Molecules and Cells

The Organisms and Population; and
Natural Communities.

These topics are based upon knowledge gained in chemistry, biology, and physics in the middle school. Thus Botany, Zoology, Human physiology and General Biology are not isolated from one another. Rather, these are inter-related sections of one instructional subject namely Biology, the phenomena of life processes including the functions of human organism as well as the common features and laws governing life and evolution of the organic world.

Returning to the topic of the article, it should be emphasised that the immediate task of physiology course is to ensure acquisition by the pupils of systematic and scientific knowledge of the structure

of human body its activities and the hygiene of the human organism; and to teach the pupils the skill to improve and preserve health.

In this course the pupils get familiar with their own bodies and the features of internal and external environment which affect their health, growth and development.

Coming after the zoology course and based on it, the course on human physiology enables a correct assessment of the place of man in the animal kingdom; explains scientifically his origin; emphasises the similarities and differences between man and animals caused by his ability to work and the environment

The course of physiology helps to form some concepts of general biology such as the cellular structure of organisms, the link between structure and function, metabolism, inheritance of characters, reflex acts of the nervous system, the humoral (chemical) regulation, and evolution of organisms. Some of the concepts about the cell, its division and multiplication, intra-cellular metabolism, the hereditary mechanism, the origin and evolution of man are dealt with only briefly in this course, as they are discussed in greater depth in the course of general biology at the senior high school.

Thus the course of physiology on the one hand is based on facts learnt in the earlier courses of botany and zoology, and on the other provides extensive factual material for further generalization in the course of general biology.

The instruction in biology in class VIII combines the fundamentals of anatomy, physiology and hygiene and includes elements of histology, embryology, microbiology, physiology of work and history of science.

At the same time the course on Human Physiology emphasises the importance of studying the functions of the human orga-

nism. The details of anatomy and morphology learnt in the course of zoology are useful in understanding functions. Topics of hygiene are given due importance in the course of biology. The organisms of animals and tissues are used as analogous parts of the human body and many audio-visual aids are also used in the teaching of this subject

Wherever possible experiments with living objects (experiments with nerves and muscular preparation of hind limbs of frog, observation of blood circulation in the web of frog's foot; cerebrospinal reflexes of the frog and micro-preparations of tissues, etc.)

Many of the problems become clear to the pupils as a result of doing independent, simple laboratory work (e.g., study of the chemical composition of bones; determination of the effect of saliva on starch paste, development, and conditioned reflexes).

The age of the pupils in class VIII is suitable for this course, as teen-agers they show a great interest in the activities of their own bodies and observe changes in it and causes for the same. The observation of their own body is very easy. For example observation of the location of bones in the skeleton, the shape of muscles contracted and relaxed, ability to taste sweetness while chewing bread, observation of rate of pulse and respiration while working and resting. This method of self-observation gives the pupils a better idea of their own organism and makes them think and creates interest in the subject.

In the course of learning facts of hygiene the pupils will have to do some practical work such as rendering first aid in haemorrhage and fracture; feeling the pulse and applying artificial respiration.

The syllabus envisages 68 periods and consists of eleven topics besides the introduction arranged in the following sequence.

1. Introduction	1 period
2. A general survey of the human body	7 periods
3. Organs of movement	6 periods
4. Digestion	7 periods
5. Blood and blood circulation	8 periods
6. Respiration	5 periods
7. Metabolism	8 periods
8. Skin	1 period
9. The nervous system and sense organs	12 periods
10. Reproduction in man	4 periods
11. Heredity	5 periods
12. Human body: its functioning as an individual	4 periods

The topics listed above have all the same structure. At the beginning of each topic the importance of the organ system is discussed, then its structure is presented to that extent as to understand its functions, and lastly its functions are discussed.

While studying each of the organs, the concept of nervous and humoral regulation of their activity is introduced and the appropriate hygiene is also discussed.

In the introduction, the importance of physiology, its link with such sciences as medicine, bionics and cybernetics are stated to create further interest in the pupils to study the instructional materials.

The topic "A general survey of the human body" is a link between the course of zoology and physiology. A brief description is given of the general features of the human organism at the level of the organ systems, tissues and cells and also the concept of control by nervous and humoral regulation of the systems into one complete organism. At the beginning of the topic the structure of the organs are studied in comparison with the structure of the organs and organ systems in mammals.

The next concept to be introduced is the

structure of the animal cell. The concept of the cell is a very important one in all disciplines of biology. It was dealt with in botany and zoology and is continued in physiology and referred to again in the course of general biology. In the present course the peculiarities of the animal cell as compared with the plant cell alone are dealt with. The knowledge of cellular structure (cytoplasm, nucleus, cell membrane, mitochondria and ribosome) is elaborated.

While dealing with the cells it is important to give some idea of the metabolism which is enlarged and made more profound in the later topics. While studying tissues the attention is centred on the properties of muscular and nervous tissues.

The pupils are made familiar with the different types of neurons and with the structure of the nervous system of man as a whole (the central nervous system, brain, spinal cord and peripheral nerves). The functions of the nervous system are also studied. By using the concepts of reflex the pupils' understanding of the nervous regulation of the activity of the organism is formed.

As humoral factors play an important role in the life of the organism and are closely connected with the nervous system the last chapter of the topic is devoted to the nervous and humoral regulation of the organism.

In the second topic "The Organs of movement" are studied. The place of this topic is deliberately kept after the general survey topic. A discussion of the structure of skeleton and that of the muscles helps to correctly understand the topography of the internal organs, the respiratory movements, peristalsis, blood circulation and so on. The peculiarities of the skeleton of man are described in conjunction with his upright posture and ability to work. Ideas about the regulation of

work of muscles, muscle fatigue and facts of hygiene are introduced in order to develop correct movements in teen-agers.

The next topics "Digestion", "Blood circulation" and "Respiration" have a common structure. The sequence of the topics enables a gradual formation of main concepts of metabolism and the role of nervous and humoral systems in the regulation of the work of the visceral organs.

The functions of the visceral organs are dealt with at the beginning of the topic on digestion. The idea of regulation by conditioned reflex is introduced by citing the example of the secretion of saliva. This topic familiarises the pupils with the role of enzymes and explains the mechanism of absorption of nutrients by the blood. In this topic of digestion the pupils could also get familiar with methods of research in physiology (the fixing of fistula in the stomach and ducts of salivary glands).

In all the three topics the structure of different organs is discussed taking into account the relevant material of the course of zoology and always in relation to their functions. These functions of the organs of digestion, blood circulation and respiration are studied through such student activities as self-observation, and rendering of first-aid in respiration and haemorrhage.

Experiments and observations can yield valuable material on nervous and humoral regulation of the organs of circulation and respiration. Unconditioned reflex regulation is shown in such organs as the salivary glands and stomach, the heart and respiratory muscles.

The humoral regulation of the activities of the internal organs are discussed through the effect of adrenalin on the heart and vessels, that of carbon dioxide on respiratory centres, gastrin and scretin on the secretion of digestive glands. The hygiene of these

topics envisages the discussion of conditions necessary for normal digestion and respiration. The facts learnt while studying internal organs and organs of movement enable a deeper understanding of the nature of the metabolic processes. Therefore, the next chapter is devoted to the general features of metabolic processes. Metabolism is described as the basic process which determines life. Its two aspects assimilation and dissimilation are considered together. The intra-cellular metabolism of protein and carbohydrates as well as the role of enzymes and vitamins are next discussed. From intra-cellular metabolism one passes on to the finding of the importance of the metabolism in the organ as a whole.

While becoming familiar with the fact of transformation of energy of the nutrients into mechanical work of the muscles, the energy spent on the work of the internal organs and the brain and the mechanism of the maintenance of constant temperature of the body are discussed.

At the close of the chapter the pupils are familiarised with the secretion of the products of metabolism through kidneys as an indispensable condition for maintaining the constancy of the internal environment of the organism.

The topic 'Metabolism' includes clarification of the importance of endocrine glands and their secretion. With the pituitary gland, the thyroid and the pancreas, it is shown that hormones influence all aspects of the activity of the organism by changing its metabolism. Diseases caused by malfunctioning of endocrine glands are discussed.

The hygiene part of the topic is represented in a separate chapter on secretion.

In the topic the 'Nervous System' the pupils generalize on the facts relating to the role of the nervous system, and learn in

detail the structure of the grey and white substances of the spinal cord; they also obtain data on sub cortex and cortex and the sense organs.

The theory of the high nervous activity is entirely new to the pupils. To facilitate a correct understanding of this an elementary idea of the sense organs and the functions of the cortex, mechanism of regulation, and the formation and inhibition of conditioned reflex according to Pavlov are introduced.

Particular attention is given to the word conditional excitor, which is specific for human high nervous activity.

Facts of hygiene are stated while studying relevant sense organ. At the end of the topic attention is given to the hygiene of mental work and sleep.

In the topic 'Reproduction in Man' the important biological question of the development of the fertilized egg is explained. Of no less importance is the explanation of the essential nature of family planning and its importance to the nation.

The problems of sex hygiene are not included in the syllabus. However, it is desirable to discuss them in talks outside the

curriculum time, separately with the girls and boys bearing in mind that at this age pupils are very sensitive to what pertains to this topic.

The topic 'Inheritance' is a logical follow-up to the preceding topic. A brief discussion is held of the laws of the transfer of hereditary features and the role of chromosomes in this process. The concept of genes is introduced as a hereditary unity, examples are discussed of the participation of genes in hereditary transfer of traits, of blood groups and sex in *Drosophila* and man.

In the concluding topic the "Human body—its functioning as an individual", the pupils' knowledge of the unity of human organism and the role of the nervous and humoral regulation in the coordination of the activity of the organ systems are generalized. Particular attention is given to the question of the effects of diseases on the normal functioning of the organism, and the measures to fight such diseases.

We believe that the points discussed in this paper will help the biology teacher to understand better the nature and peculiarities of the human physiology course for the middle school.

The Development of Primary Science Education at NCERT

B.D. ATREYA, Department of Science
Education, NCERT and

A.W. TORRIE, UNESCO/UNICEF Science
Consultant, Department of Science Edu-
cation, NCERT, New Delhi.

The guide lines for the development of any school curriculum must always have regard for the needs of society as a whole and the consumer. Once the guide lines have been established, the next step is to write a syllabus which will provide the basic framework for the production of textbooks and other teaching materials.

In 1963, the National Council for Educational Research and Training published a *General Science Syllabus—Classes I to VIII*. In the following year the UNESCO Planning Mission made a recommendation that science be taught as separate disciplines from Class VI onwards. This was confirmed by the Kothari Commission Report in 1966. Accordingly, the 1963 *General Science Syllabus Classes I—VIII* was revised and published by NCERT in 1967 as the *General*

Science Syllabus, Classes I—V. It should be mentioned here that the syllabus was rewritten according to recommendations of the Kothari Commission Report which stated that the focus of science at this level should be on the child's environment—social, physical and biological. The accent should be on the formation of healthy habits and the development of the child's powers of observation.

The 1967 syllabus was reviewed at a National Seminar in March 1968. This "Seminar of Primary Science Teaching Materials" included representatives from State Institutes of Education and other Teacher Training Institutions throughout India. In view of the recommendations made by this experienced body of educators in their Report, the syllabus was again revised and has been published in cyclostyled format in September, 1969, under the heading *Science for Primary Schools, Classes I to V*.

The structure of the present syllabus is based on eleven units which may be grouped into three major sections, the earth related sciences, the physical sciences and the biological sciences. Each unit of the syllabus is structured in such a way that the children's knowledge and understandings of science are expanded in a logical, sequential fashion throughout their primary school years.

There are many divergent views about the nature of science and the ways by which it may be taught. Some believe that science is simply a collection of theories and principles, facts and formulae, techniques and terminology. This, however, is not the true concept of the nature of science, for besides these important facets of the subject, there are also basic attitudes and approaches which must be considered. These two complementary aspects of science may be

described in terms such as content and method, or product and process.

In past generations, science has been taught in our schools through the assimilation by child, of the products of science. Teachers have leaned heavily on the talk and chalk method of instructing their pupils, who have merely become semi-receptive sponges for an accumulation of facts and figures, theories and formulae. With the rapid development of technology in the last generation, there is an increasing need for trained scientists and technicians in all countries. Unfortunately, the number of high school pupils entering these fields has remained at a very low level and it soon became obvious to educationalists the world over, that science teaching techniques needed a very close scrutiny.

During the last decade, science educationalists throughout the world have carefully examined syllabuses and textbooks, methods and teaching techniques in all areas of the school stage. Universally, it was found that the education of the child prospered, when he was actively engaged in practical learning situations. The enquiry method or discovery approach has become the base on which current science education programmes are being built.

Teaching Materials.

At all levels, whether it be in the infant room of a primary school or graduate class at a University, the important catalyst in all learning situations, is the teacher. It was early realised by NCERT staff that if the new syllabus is to be used effectively in primary schools throughout the nation, practising teachers must be re-orientated towards the new techniques and future students of the teacher training schools must have an adequate source of teaching materials. With this in mind, the staff of the

Department of science Education, NCERT, in conjunction with an overseas consultant, produced a Teachers' Handbook of Activities for Primary Schools. This Handbook has been printed in three volumes and should give teachers and students alike, invaluable guidance for their teaching of science in primary schools. (*General Science for Primary Schools—A Teacher's Handbook of Activities* Vols 1—3, 1967-69).

The Handbook has been written for primary school teachers in India and has regard for teaching in the regional languages of village or city schools in rural or urban environments. The writing panel realised that science could be effectively taught at the primary school level with simple equipment which may be readily obtained from the child's environment. Consequently, most of the activities described in the text do not require special laboratory equipment.

The writers also realised that many children leave school even before they have completed their primary schooling. So they have attempted to give as much information as possible to enable the teacher to impart to his pupils, as much knowledge as possible in their early years at school, about the physical, biological and earth science aspects of the environment with particular emphasis on health and hygiene.

In order that the Handbook may be put to the most effective use by the teacher, it is important for him to thoroughly read and re-read the introduction to the Handbook.

Why Teach Science to Children?

This question is posed on the first page of the Introduction and the answer is effectively given in the text that follows. It accurately interprets for the teacher in simple terms, both the 'product' and 'process' of science. It explains that while the 'product' of science which includes a knowledge of

facts and formulae, concepts and principles, techniques and terminology, is well known the world over, it is the 'process' of science which has become the corner-stone of modern science education.

Science processes include all the ways by which scientific concepts and principles may be examined. Such processes include observation and measurement, inference and prediction, classification and the recognition of time/space relationships. In all, some fourteen or fifteen scientific processes may be identified, but many of them are applicable only at the higher secondary school level.

The activities described in the Teacher's Handbook, include all of the scientific processes which are valid at the primary school level. These activities are pupil centred and unless a teacher is willing to allow his pupils to actively participate in practical learning situations, then the complete philosophy of the Handbook is lost.

Textbooks for Children

Once the basic framework of the syllabus had been laid and the roof and walls of its structure established in the Teacher's Handbook, the next step was to put in the joinery and lining for the comfort of the consumer. The consumer of course, is the pupil, the joinery and lining being the textbook for the pupil's use.

There is no textbook for Classes I and II because children at this level are just learning to read. It is possible that readers could be published for these classes with a slight science bias, but this is a matter for future exploration and development. While the writing of the Class 3 textbook commenced in 1968, the true structure of the text did not emerge until early 1969, when writing activity was renewed. In late April an experimental textbook entitled *Science is*

Doing was printed by the Department of Science Education. This text contained five representative chapters of the complete textbook. Its purpose was to test the language level and suitability of activities and equipment in a limited number of Delhi primary schools.

The title *Science is Doing* emphasises the underlying philosophy of the textbook, which endeavours at every possible stage, to involve the pupil in practical investigations for himself. The equipment used for these practical activities may readily be found in the child's village or city environment. Above all, the activities had to accommodate the 8-or 9-year old child's ability to co-ordinate hand, eye and mind.

It was also recognised that a content summary had to be included for the child's benefit at the end of each chapter. Furthermore, questions were needed which would enable the child to test for himself, what he had learned.

Testing the Textbook

As mentioned previously, a half volume of the textbook was printed for experimental testing in a number of local schools. Three schools were subsequently chosen for this experiment and the teachers of Class 3 pupils were brought together at the Department of Science Education, NCERT, for discussions concerning the proposed classroom testing.

It was obvious at the outset, that average classroom teachers have considerable difficulty in assimilating and understanding the new methods of science teaching. Subsequently, when the book was tested in the classroom, the writers were required to examine their own philosophies by doing much of the teaching themselves. This turned out to be a blessing in disguise because it gave the writers an even closer understanding.

of the intellectual abilities and needs of children of this age.

Before the textbook was used in each class a short objective test was given to each child in order to assess his knowledge of the subject. After the chapter had been taught through class discussion and group or individual activities, the same test was given to each child in order to assess what he had learned. While the results indicated that this kind of evaluation was extremely useful, it also showed the writers that each test had to be very carefully constructed and worded, if the work was to be effectively evaluated. It is obvious, that for future evaluation procedure, expert advice is needed from practising educational psychologists who have a good knowledge of primary school children.

In the beginning, the children's reaction to the novelty of discovering things for themselves through experimental activities brought about an apparent discipline problem in the class, because of the increased noise from group discussions and movement about the room. The class teachers were a little unsettled by this change in classroom atmosphere and it required further discussion to reassure them that this change was in fact beneficial. The reaction on the part of the teachers also gave NCERT staff an insight into a practical problem which would confront practising teachers and school inspectorate alike. Their own attitudes towards classroom behaviour and discipline would have to be modified, if the enquiry approach to primary science teaching throughout India was to be successful.

The direct involvement of the writers in the classroom testing of their textbook had additional benefits. Besides indicating that some of the concepts underlying a number of activities were too difficult for the children, particularly in the physical area, the

classroom tests also showed that some aspects of science which had been left out of the Class 3 syllabus, were of great interest to children of this age. Accordingly, small changes were made in the syllabus to accommodate this interest that had been discovered in the children. The particular instances refer to the handling of magnets, magnifying glasses and mirrors by the children; something that was almost accidental. On careful examination of a representative number of overseas text books, it was discovered that many texts included activities involving magnetism, light and electricity at this age level.

The accompanying photographs were taken during the course of the experimental classroom teaching and will give the reader some idea of the reaction of the children to their practical activities. It will also give some idea of classroom organisation. In order to gain the maximum benefit from group activity, it is necessary to rearrange the pupils' desks or tables into groups of four or five. In village schools where much of the teaching may be done outside, the children may be re-arranged into groups of four or five.

It is clearly understood by the writing panel that the results of these brief classroom tests of the textbook are not the final word, and that further testing and evaluation must be carried out on a nation-wide scale, in order to establish the true needs of both children and society. Ideally, evaluation committees should be set up in each State, which should test the textbooks over a period of two or three years with feed-back to a panel of writers who would then re-write the textbooks and perhaps the syllabus in the light of this evidence.

Practical and Textbook Guide

It was mentioned earlier in this article

that the teachers had difficulty in understanding the basic classroom needs of the enquiry approach to primary science education. The writing panel recognised that additional assistance for the teacher was needed if he was to effectively use the new textbooks. Accordingly a *Practical Manual and Kit Guide for Class 3* was written and published for the assistance of teachers. This guide contained descriptions and illustrations of each activity and a series of questions which the teachers could use to both guide the children's practical work and stimulate their minds along the right lines. This guide was discussed by both teachers and teacher-educators and was subsequently rewritten. The revised version detailed the philosophy underlying each unit and showed how each major idea or concept was to be treated in the textbook. Furthermore, it gave detailed information about the aims and objectives of each activity and included directions which the teacher himself might find useful in teaching his class. The questions were revised and model answers were given to each one, for the guidance of the teacher.

It is expected that this guide will be further modified in the light of practical classroom use during the first two years of the Pilot Programme in State schools.

Leadership Training Courses

The success or failure of any new syllabus and its accompanying textual materials stands or falls on the effectiveness of teacher training programmes. The necessity for such programmes had been early recognised by NCERT and provision was made for a leadership training course to be held on the National Institute of Education Campus, New Delhi in June, 1969. The object of the Course was to acquaint teacher-educators in the State Institutes of Education with

the new philosophy of science education and the new materials.

The Course took place as planned in June last, being attended by 17 participants from 10 different States. To some extent, the non-participation of 7 states was a little disappointing, but transport difficulties at that time within the country and the late delivery of some invitations were contributing factors. Since many intending participants were delayed for various reasons, the programme for the Course was redrafted on June 3 by a committee of NCERT staff and consultants, assisted by Course participants. This involvement of participants in the direction of the Course became a guiding principle and greatly assisted the interchange of ideas between staff and participants.

The first week of the Course was devoted to an exposition of the philosophies and presentation of materials produced by many elementary science programmes both at home and abroad. A number of films illustrating such programmes in action in classroom situations, gave an insight into the workings of many projects. The mornings were devoted to lecture/demonstration/discussion sessions including participation in practical activities and the viewing of films. The afternoon programmes involved participants in the practical activities of the Class 3 textbook and a review of the Teachers' Handbook and the Class 3 Practical Manual. While the activities merely repeated what the children were expected to do in classroom situations, the discussions that followed took place at the teacher-educator level. The objectives of each activity were not taken for granted and there were many stimulating arguments and discussions during the week.

The Course was fortunate in having three full time overseas consultants, all

of whom were conversant with elementary science programmes. While their experience gave a useful direction to the Course, the staff of NCERT and the participants from the States, showed that they were more than conversant with modern methods of science education. While a large number of overseas consultants attended the Course from time to time and gave very useful lectures or demonstrations, there was a feeling, that in some cases the content of their exposition was rather removed from the elementary science scene. Nevertheless, the repeated exposure to new ideas and philosophies gave additional experience to all present.

Among the films that were shown included three excellent titles which were enjoyed by all present, both for their presentation and the new ideas that they contained. The films were entitled "The Growing Mind", "Stages of Learning" and "How Children Think", all produced by BBC/TV. By demonstrating a number of original experiments from the research of the famous Swiss psychologist Piaget, the films gave an excellent appraisal of the need for textbook writers, curriculum developers and educationalists in general, to understand the stages of development of the intellects of primary school children. The impact of these films was so great, that all present recommended that films of this kind, depicting Indian children being taught by Indian teachers in Indian schools would be invaluable to teacher-education throughout the nation. It is hoped that this challenge will be taken up by the authorities concerned.

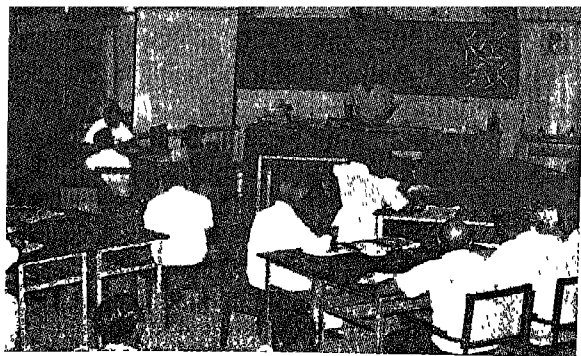
During the second and third weeks, the participants had the opportunity of reviewing the activities that would be incorporated in the Class 4 and 5 textbooks. They were also acquainted with the materials that had been produced by NCERT for their

middle school science teaching project and study group programmes. The various kits which had been designed to accompany the former UNESCO-aided programme were demonstrated to the participants who were informed that prototypes were available to each State which wished to manufacture its own equipment.

Another highlight of this period of the Course was participation in a series of lecture/practical periods of science process learning, conducted by the participants themselves. Each of these periods was accompanied by animated discussion which testified to the effectiveness of this kind of teaching method at the teacher-educator level. Many commented favourably on the heavy practical bias of the Course and stated their preference for this approach over the old talk and chalk, lecture method.

The NCERT staff also felt that it was important to emphasise the need for teachers to be able to improvise and make their own simple science equipment. To this end, 8 models of such equipment had been designed and produced in the Central Science Workshop. For three mornings the lecture room was turned into an improvised workshop with simple wooden benchhooks in place of vises and tables in place of benches. Using readily available hand tools, such as saws, hammers, hand-drills and screwdrivers, all of the participants and many of the staff of the Department of Science Education made two or three pieces of equipment during the time available. The success of this 'workshop' period was indicated by the unanimous recommendation, that NCERT produce a Handbook which would give the plans and specifications for about 40 such models and would include some information about the care and maintenance of hand tools.

The last week of the Course was given



LEADERSHIP TRAINING COURSE, JUNE 1969

A lecture in progress. This shows the informal arrangement of the tables to facilitate practical work. Most lectures included participation in practical work.

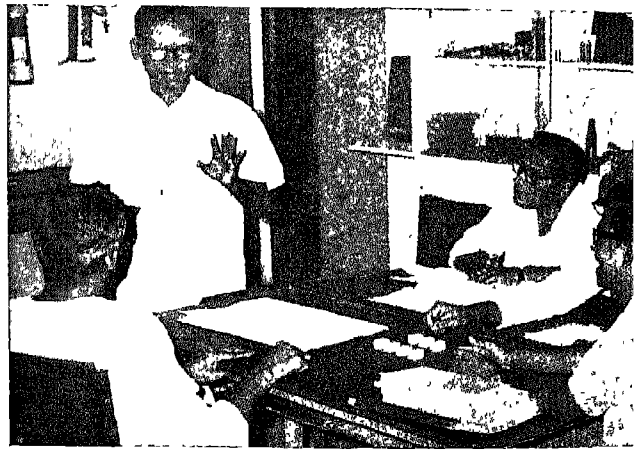
Here, participants are conducting a practical period on science process teaching with the rest of the group.



A feature of the Course was the workshop session where participants were shown how to use hand tools for the construction of simple science equipment.



Even ladies enjoyed the handling of tools and the making of equipment during the workshop periods



A group discusses a practical aspect of science process teaching.



Drinking straws may be used for more than one purpose!



TESTING A TEXTBOOK

Lessons were sometimes introduced with the desks and tables arranged in the usual formal manner. They were then rearranged for group activity.



The central space left in the classroom may be used for more physical activities, such as this investigation of the force involved in pushing.

the State Institutes of Science Education and Institutes of Education according to the equipment list drawn up by NCERT. Furthermore, it was also agreed that UNICEF would supply a limited number of Teacher Training Colleges and Teacher Training Schools in each State with equipment according to the schedule. The States who agreed to participate in this Pilot Programme would then select the key institutions most suitable to its purpose and nominate at least 30 primary and 30 middle schools, preferably located near the key institutions. The Class 3 and Class 6 materials developed by NCERT would be made available to the States for translation and enough books would be printed in each State to support the Pilot Programme in the selected schools. Assistance would be given by Government and UNICEF to meet

the cost of translation and printing.

The Pilot Programme would be tried out in the States on a limited experimental basis, with periodic evaluation and feed-back to State Institutes of Education and to NCERT with a view of improving both syllabuses and textual materials.

In many ways the delay in this Project is a blessing in disguise, because the Pilot Programme will now give each State ample opportunity to experiment with and evaluate the NCERT materials which may then be rewritten in the light of their experimental use. The important thing to remember is that a syllabus and its supporting textbooks are only as good as the teachers who use them. Therefore, a great deal of emphasis must be placed on teacher training and in-service training for teachers throughout the whole period of the Project.

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Science Education and Investigative Project

OM SARASWAT
Jaipur

IN a society where the pace and magnitude of change and growth of knowledge is very rapid, we can not stick to an educational system which stresses 'fact digesting' rather than 'fact finding'. Students in our country are supplied with certain facts in a stereotyped manner and they are expected to 'digest' them without asking 'hows' and 'whys'. A list of twenty to twenty-five experiments is hanging on the walls of the school laboratory, and students perform them in a very conventional manner with the help of apparatus about which they know little. But is that a Science? Science is certainly not a bundle of facts handed down from one generation to another, its purpose is not even to perform twenty or twenty-five experiments in the laboratories for examination purposes, and it is not even a mere collection of

the data, but as Fitzpatrick Frederick wrote: "Science is a cumulative and endless series of empirical observations which results in the formation of concepts and theories, with both concepts and theories being subject to modification in the light of further empirical observations. Science is both a body of knowledge and the process of acquiring and refining knowledge."

Every child by nature is an experimenter. He is curious and sensitive to his environment and wants to test and judge every phenomenon. Even outside the school he is constantly experimenting. Many young people would like to design apparatus and to test the ideas proposed in their classroom. They want to know how density decreases with the rise in temperatures and how solubility of a substance is affected by temperature? Obviously such questions can better be answered in the laboratory.

A curious child's mind goes still further. He raises the questions, "Is there any effect of coloured light on the growth of plants"? Such a student can not be satisfied by simple drab and formal classroom activities. To help the child in finding out answers to such questions, a teacher should be resourceful. A teacher should give students a chance to learn to question and not to take things for granted. With challenge and questioning, starts the process of scientific and creative inquiry. Teachers should encourage the students to test their hypotheses and then to find out the facts themselves. Conducting experiments means challenging the facts and finding out answers for oneself, this process of challenge and guessing and finally testing, gives the student a profound joy and satisfaction. He finds for himself what others say in pedestrian textbooks. Habit of enquiry, discovery, experimentation, exploration,

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manipulating and investigating lie at the base of science and science teaching. Researchers in the field of psychology have found that this joy of experimentation is most important in becoming a productive scientist.

Science Education and Investigative Projects

There is a common saying, "Teaching is more than the presentation of facts. Teaching is the development of new ways of thinking—a development that reveals itself in increased skills with the problems of life, in new habits of action, in more desirable attitudes, in a benefitted personality and in an improved character." That is really an objective of education in general. Science education, too is fruitless until it brings a proper behavioural change in the students. The present educational system (with particular reference to science education) is most conventional in nature and does not provide the students an environment for their proper development. According to Education Commission Report (1964-66), "school curriculum is inadequate and outmoded, and not properly designed to meet the needs of modern times." It further states, "there is a good deal of useless educational lumber in the school courses which can be safely discarded, and more dynamic and stimulating methods can be developed for presenting essential knowledge". Science education, too needs outright change. It requires reappraisal. The major step towards strengthening science education according to the Commission is "recognition that teaching and research are mutually supported activities. High quality teaching in science is possible only in a research environment. Research is essential for its sustenance". Thus investigative projects should be made part and parcel of secondary and higher secondary

levels. Simple experiments are found more fruitful because they are not only simple but within the purview of the school laboratory too. Anyhow complex phenomenon too can be investigated with the help of college or university laboratories.

Thus investigatory Projects are those projects, "which involve a reach to understand the unknown, and being with a question". Here are some Investigative Projects for the students of Secondary and Higher Secondary levels.

Physics

1. Is there any mathematical relationship between the bouncing percentage and density of surface material when a steel ball bounces on a solid steel surface, a rubber surface, a wooden surface, a card board surface, a linoleum surface or others.
2. Does the tensile strength of hairs of different species vary?
3. If you let a drop of ink fall from a fixed height it makes a spot peculiar to its nature. How many questions arise at this point. In what ways do the number of rays vary with the distance the drop falls? Can the height of the fall be related to the length of the rays, the forms of the rays and diameter of the main body of the sputter?
4. If a body is dropped from a fixed height in different viscous liquids, does any relation exist between the velocity of the body to the densities of liquid?
5. Does the capillary action in different liquids vary?

Chemistry

1. Does any mathematical relation exist between water of crystallisation and molecular weight of a crystal?
2. Does the temperature effect the solubility of substances?

3. Does the temperature effect the crystal growth?
4. To study the effectiveness of dehydrating agents.
5. To study the miscibility of two compounds (liquid).

- (a) Miscibility of alcohol and water.
- (b) Miscibility of phenol and water.
- (c) Miscibility of carbon tetrachloride and water.

Biology

1. Does the coloured life effect the growth of bacteria.
2. To study the ratio between the growth of length and diameter of different plants.
3. To study the effect of gravity on roots.
4. To study the effect of temperature on the activity of yeast.
5. To study whether bacteria grow best where it is moist or where it is dry.

But it is important to note that Investigative Projects are not merely the set of questions put by the students or teachers in the class, but they involve the study of nature too. Collecting all kinds of plants available in the nearby locality and arranging them in a Botanical order is a very good project. With the help of the local municipality office, students can find the population growth per year in the locality. Students can also study on butterflies, spiders, honey bees, cockroaches, beetles etc. Through such studies students can bring themselves near to nature and can understand natural laws properly.

With the help of the school observatory, the students can display the observations daily on the notice board. It will give proper information to the students about the time of sunrise, sunset, maximum temperature in 24 hours, total rainfall in the last 24 hours. It will mean mak-

ing them more sensitive to the environmental stimuli. Young astronomers should be guided to improvise their own instruments. That will develop confidence and joy in them.

Selection of Investigative Projects

A Proper selection of Investigative Projects is extremely important. The following facts should be kept in mind while selecting Project for Investigation..

1. Projects should be selected according to the standard of the students. Students must be familiar with the background of the projects. If in an investigation a certain formula is to be used, the student must know about it fully.
2. As stated previously, problems should be as simple as possible. They must fall within the purview of school laboratory.
3. All the apparatus used in the Project should either be available from the school laboratory or be improvised by the students themselves. In special cases apparatus can be borrowed from the neighbouring schools.
4. In the present state of affairs we cannot afford costly projects, hence the cost should not exceed, in most of the cases, Rs. 5/- per student.
5. While selecting Investigative Projects, the students should not remain passive. Students too have original ideas and their participation and involvement is crucial for developing a scientific spirit and a scientific attitude. A teacher should think with the students and jointly they should perform the experiment.
6. Projects should not consume too much time. An investigation needs two things: patience and labour--two things that children usually lack. So while selecting Projects it should be kept in mind that the results should be obtained in a short period.
7. Students should be encouraged to

establish their own laboratories at their homes where they may utilise their leisure in a fruitful way.

Keeping the above facts in view the teacher should select the projects and distribute them to the students according to their choice. For those projects which are complex and time consuming, a group of students should be selected. After the distribution of projects the greatest task of a teacher lies ahead, that is guiding the students.

Giving Directions for the Investigative Projects

While guiding the students, the teacher should consider himself simply a guide and not an experimenter. Projects should be well guided. Improper guidance leads either to failure or boredom. Directions can be given orally as well as on the black-board. The following example will illustrate the proper use of the black-board.

Experiment: Is there any effect of an electric field on chemical reactions?

Materials

required: (1) Sugar
(2) Beaker.
(3) Enamelled wire
(4) D.C. supply.

Procedure: (1) Prepare saturated solution of sugar.
(2) Suspend a crystal of sugar in solution.
(3) Around the beaker wind the enamelled wire.
(4) Pass fixed amperes of D.C. from supply.
(5) Weigh the crystal after every 12 hours and see if there is any change in the rate of crystallisation.

(6) For standardisation, another saturated solution of the same strength can be prepared.

(7) Increase the current and see the effect.

Such types of instructions will just show the path to the student. While performing an experiment the student should feel the difficulties a scientist encounters while performing an experiment. Professional scientists devise their own experiments, meet difficulties as well as success, try things out with a watchful eye and a critical mind. A student too should feel likewise.

Students should be made aware of the precautions they have to observe. While doing experiments with poisonous insects, special precautions should be taken. Highly dangerous projects may be avoided.

Reporting the Projects

When the student has performed the experiment and has drawn the conclusion from the data obtained, he should be asked to write the report in detail.

The detailed report of the project must touch all the necessary aspects of the experiment. It must include the hypothesis, name of the student, material used, sources from where the material was collected. If any apparatus is improvised its procedure should be written. The procedure of the experiment must be written in detail. If the student has used a formula, he must write from where it is obtained and how it is deduced. Then comes observation. All the data collected should be displayed in a most appropriate manner. The result obtained should be expressed properly. Graphical representation of the data is essential whenever possible. In concluding remarks, the student may point out the

possible reasons for the results obtained and may suggest research ideas for further investigation. If possible the overall cost of the experiment may be reported. The report should include a comprehensive bibliography as well.

Such a project report will add to the experiences of the child. When all the project reports are collected, they should form one volume and should be kept in the school library for reference.

Investigative project aim at not only producing Nobel Laureates and topmost scientists but they essentially aim also at producing discoverers who feel profound satisfaction in conducting and testing certain phenomena. This philosophy of investigative projects will go a long way in developing creative talents, (Raina and Piyush, 1969), and critical and problem solving thinking and, in this way it will help the realisation of essential objectives of science education. The author of this paper who has launched this movement¹ of Investigative Projects in his school has really

seen in practice now young potential scientists develop such abilities.

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The Shipworm A Timber Destroyer par Excellence

N. BALAKRISHNAN NAIR

Professor of Marine Biology & Fisheries,
University of Kerala, Trivandrum

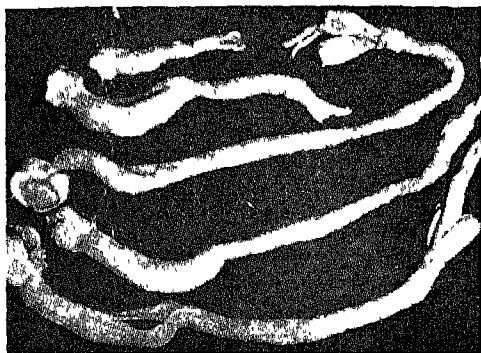
A UBIQUITOUS pest of all sorts of timber in the sea, teredo, the shipworm, causes damage valued at crores of rupees every year all over the world. Hidden protectively within the heart of both fixed and floating timber and hardly visible from the outside, these borers work silently and steadily along the entire coasts of the continents and islands. Effortlessly rasping with their shells, countless batteries of these living drills reduce to soft saw-dust timber of even the most resistant types and amazingly draw a major part of their nourishment from the hard cellulose. The accounts of the voyages of Dampier, Cook and Drake reveal that these early navigators dreaded the shipworm. Columbus lost all the ships of fourth voyage, as a result of the ravages of the shipworms.

For all maritime nations this innocent looking, soft, naked creature has been

enemy number one. Though present in all the seas of the world, the shipworms are particularly destructive in the warm waters of the tropics where they eat up indiscriminately every material of plant origin. In India alone millions of rupees are spent every year for replacement of piles, jetties, fenders, boats, catamarans etc., destroyed by these organisms.

Only remotely resembling a worm and wrongly named shipworm, the teredo is in reality not a worm but a distant cousin of the clams, oysters and mussels and belongs to the group of soft-bodied animals known as molluscs. Unlike its relatives, teredo has a long, slender and soft body and the bivalve shell has lost its protective function and has become small but highly specialised as a drilling tool. Its unusual life within the wood has thus made it very different from its relatives both in appearance and in habits. The naked body projects out far beyond the shell valves and the only visible parts of the shipworm in its natural condition are the two tubes at the posterior end of the body called the siphons used for the inlet and exit of the water into and out of the body. These are seen displayed through small holes which represent the points of initial entry of the creatures into the wood. The shell functions as a mechanical drilling organ and since the animal feeds on the saw dust thus produced, it can be considered as a feeding organ as well. Armed with numerous rows of sharp, microscopic, rasp-like teeth and powered by two unequal adductor muscles these valves are capable of rocking back and forth on special knobs for tunnelling into even the hardest varieties of timber. The foot has become almost circular and can be protruded forwards through the widely gaping shell and is used as a sucking disc at the blind end of the burrow while the animal is at work with the

shell. The creature on entering a wooden structure feeds on the very material it bores into and grows in length with astonishing rapidity.



Teredo—the Shipworm

Entombed within the wood, the shipworms spend their entire adult life in the darkness of the burrows, the only communication with the ambient water being through the pair of siphons. The animal fills its burrow and the soft outer skin called the mantle secretes a calcareous tubing between the body and the walls of the burrow to protect its naked body from any noxious substances present in the timber.

Rarely among animals, teredo is endowed with this remarkable power to convert cellulose into assimilable glucose with the help of enzyme systems.

A pair of calcareous pallets present at the posterior end of the body are used as conical plug sealing the circular opening of the borrow when the siphons are withdrawn. This is to protect the soft animals within the burrow from poisons and enemies and to seal them off from outside in times of exposure. These unusual shields have faithfully saved their owners from external danger.

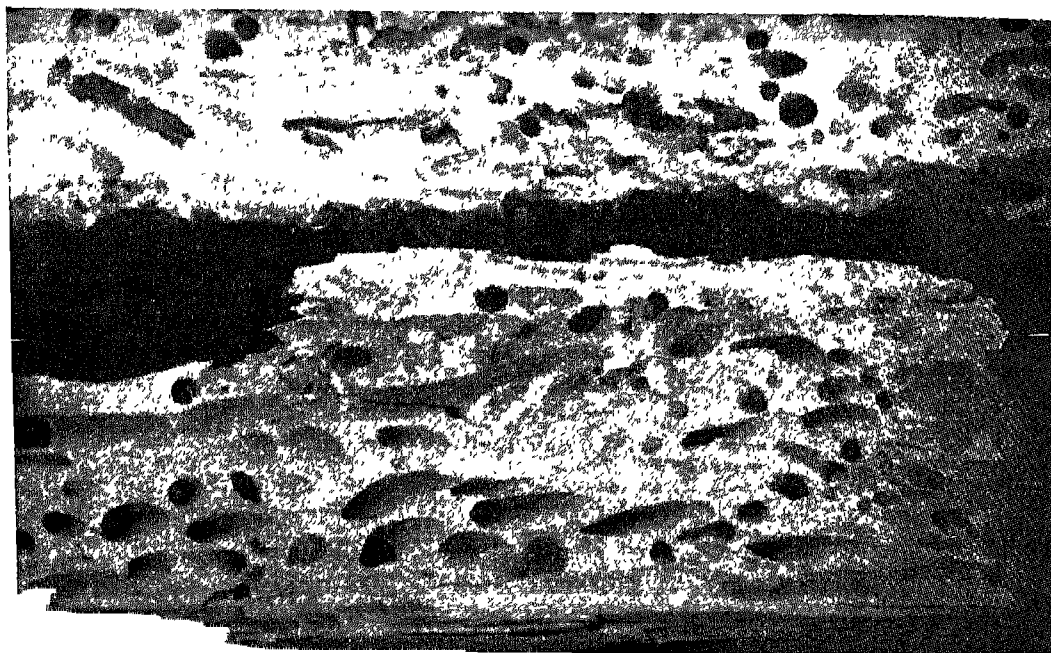
While a few species of shipworms can grow to a length of more than a metre and

the thickness of the index finger, the majority are small, hardly more than a foot in length. Despite their smallness their reproduction and growth rate are unbelievably rapid and the density of settlement is high. Attaining sexual maturity at a very early age, they produce generations of off-spring in a single year in the favourable warm water of the tropics. In the tropics even the most resistant kinds of timber succumb to the concerted onslaught of successive waves of bores.

The shipworms get distributed far and wide through their free swimming larval stages. While some species liberate eggs into the water where they get fertilised and develop into tiny larvae called veligers, others brood the eggs within their bodies from which the veligers are released when ready. During the latter part of free swimming life, if confronted by a piece of timber, the larvae settle on it, select a suitable spot, throw off the swimming organs and transform into tiny timber boring shipworms. This period is the most important period of their life history from the point of view of man since it is at this stage that they come into contact with wood and begin their destructive activity.

With their characteristic boring habits and a boundless appetite for wood they attack vegetable matter of every description both living and dead. The attack of shipworms is not only confined to floating objects like boats, floats, buoys, barges, docks and dolphins or to fixed objects like pillars of piers and wharves, stakepoles, but also to such objects as wooden pipe lining, hemp ropes, corky seeds, cocoanuts and jute or guttapercha covers of submarine cables.

The protected, entombed life of the shipworm has necessitated special and sometimes novel devices to detect their presence within a pile or a piece of timber. In their



Pieces of timber destroyed by shipworms at Cochine harbour

natural habitat they may be found out with the help of divers who can look out for the display of siphons which are their only visible parts. Since these borers produce a characteristic rasping sound while abrading wood with their denticulated shells, engineers use electrical stethoscopes and microphones to pick up the noise during the inspection of piles. Recently X-ray has also been employed for the detection and study of shipworms. This facilitates not only the detection of their presence but also the details regarding the growth rates of their calcium lined burrows.

The introduction of poisons into the surrounding water, nailing, fixing shingles or glass particles over exposed concrete or any such suitable wrappings, metal bands or pipe casings or collars for piles, piles with poison

in the core have all been desperately tried from time to time to get protection from borers. In Roman times, ships in the Mediterranean were sheathed with metal and in the reign of Henry VI lead was employed for the protection of ships.

The discovery that a severe shock such as pile-driver blow is detrimental to shipworms within a pile soon found application in the fight against teredo. Thus dynamite was employed in the vicinity of teredo infected timbers. It has been claimed that a blasting schedule of two month intervals increased the service life of piling to 3 or 4 years. The procedure consists of detonating from 10 to 20 charges of high explosive simultaneously in the water between piling at low tide. Tests indicate that 75% of teredo infestation is destroyed by this procedure.

This promising method is at present extensively used in the Canadian logging industry.

Electrolytic protection is yet another device. Here alternating rows of iron and copper nails or strands of copper and iron wire are used around a pile or wooden surface that needs protection. The electrolytic action taking place in the wood soaked with sea water results in the deposition of iron oxide in the surface layers of wood and this apparently prevents the entrance of borers.

Electrolysis of sea water and the liberation of chlorine as a measure to suffocate and poison the shipworms within their borrows, though suggested repeatedly with interesting modifications, was subsequently found to have no appreciable effect on established borers in piles.

Scientists even tried electrocution as a possible measure to destroy the shipworm, by passing an electric current of high amperage and voltage with special devices. The real effect of these tests have not all been reported.

Of the various methods used to protect timber against borer attack chemical treatment appear to be the most practicable and widely used. The Egyptians with their expert knowledge in the preservation of dead bodies also developed effective methods for

wood preservation. The submarine survey in the Mediterranean by the French Navy brought to light hulls of ancient sailing ships which had remained submerged for more than 20 centuries with timber still perfectly intact. Arabs and Indians have also been adventurous mariners maintaining large fleets of sailing vessels both for colonisation and commerce. The best anti-teredo weapon known at present is impregnation of timber with creosote. In the United States tar is added with a view to prolonging its effectiveness. But even these leach out in course of time leaving the surface exposed to borer attack.

Biological control is a natural method. Several parasites, predators and associates are known for shipworms such as protozoans, planarians and polychaetes. Some of these are known to attack and devour them piecemeal. Dr. Ruth Turner of Harvard has recently suggested that certain species of marine flatworms eat the eggs of teredo and she believes that if the flatworms were let loose in badly infested area they might wipe out these destructive borers.

Detailed studies are being conducted in the University of Kerala on the several aspects of the marine borers including the possibility of biological control of these pests.

India's Success with Dwarf Wheats

M.S. SWAMINATHAN
Director, Indian Agricultural Research
Institute, New Delhi

DURING the last few decades wheats yield in India have been stagnant at about 800 kg per hectare. Total wheat production, however, rose steadily from about 7 m. metric tons in 1951 to about 12 m. in 1964-65, thanks largely to an extension in the area under the crop. There are at present about 13m. hectares under wheat, of which about 4m. have assured irrigation facilities fed by either canals or tubewells and ordinary



Four different wheats: (1) tall, (2) single-gene dwarf, (3) two-gene dwarf, (4) three-gene dwarf
Reprinted from SPAN 11 (3), 1968.

wells. Even in irrigated areas, the average yield has been of the order of only 1.3 metric tons per hectare.

Scientific wheat improvement work started in the early years of this century at the Indian (then Imperial) Agricultural Research Institute under the guidance of Sir Albert Howard. This work led to the development of varieties like NP4 and NP52 which were capable of yielding about 3,000 kg per hectare under good conditions of management. In 1935, Dr B.P. Pal reoriented the programme so as to incorporate a high degree of resistance to stem, leaf and stripe rusts in the cultivated varieties. Some of the varieties resulting from this programme, such as NP710, NP718, NP770, NP798 and NP809, became quite popular, and in years of severe rust epidemics, farmers could harvest grain only from these strains.

Breeding programmes were also initiated in the different states of India, and some notable varieties like C591, C518 and C281 were developed in the Punjab by Mr. Ram Dhan Singh.

These Punjab wheats led to a preference in the grain market for bold, hard, amber and lustrous grains. Before their introduction in 1934, varieties with red grains were also widely cultivated and the present preference for amber grain did not exist. Throughout the country, however, there was preference for hard and vitreous grains both because such wheats make good chapatis (unleavened bread, the form in which wheat is consumed in India) and because they store better under primitive conditions of grain storage. The soft wheats are heavily damaged by grain weevils during storage in mud bins, and there has therefore been an unconscious selection for wheats with a higher Pelschenke value (a unit of measurement of gluten strength). There are nearly 1.5 m. hectares under the tetraploid wheats, *Triticum durum*

and *T. dicoccum*, which are widely cultivated in many parts of peninsular India because of their resistance to drought. The common bread wheat, *T. aestivum*, is the dominant wheat of the Indo-gangetic plains.

In 1961 I made a study of the factors responsible for the yield stagnation as well as instability in the production of this crop. The following appeared to be the principal factors involved. First, the morphology and development of the tall varieties being cultivated were not conducive to the crop being grown under good condition of soil fertility. Secondly, the tall straw and the consequent low resistance to lodging made irrigation impossible after about February (wheat is sown in most of India in October-November and harvested in March-April); the temperature rises rapidly and exceeds 30°C from March, so the plants experience both atmospheric and soil drought during the grain development phases. This is why Sir Albert Howard commented over 50 years ago that 'wheat yield in India is a gamble in temperature'.

Thirdly, most of the common wheat varieties, with the exception of those bred at the Indian Agricultural Research Institute, were susceptible to rusts and loose smut, and whenever more water and nutrients were supplied to the crop, the disease problem became more severe. Finally, late rains and hail storms and heavy wind are recurrent during late March and the tall varieties invariably lodged even under conditions of low fertility. An important consequence of lodging is a delay in maturity and the shifting of grain development to more unfavourable environmental conditions than normal. This analysis led to the conviction that dwarf wheat varieties are essential both for increasing the yield potential of the crop through the effective use of water and

fertilisers, and for destroying some of the factors causing instability in production from year to year.

Genes for Dwarfing

The discovery in Japan of genes in the Norin wheat variety, which confer a dwarf and non-lodging plant habit, opened the door to the reconstruction of the morphology of the wheat plant. Several dwarfing genes had for long been known in wheat, such as the *S* or *C* genes which govern the Sphaerococcum and Compactum characteristics respectively. These genes, however, produced coincidentally with dwarfing, very dense and compact ears. The first variety which appears to have had the desired combination of short plant height, lodging resistance and ear characters was Norin 10. This variety was one of a collection of Japanese wheats brought to the United States by Dr. S.C. Salmon in 1946. Three recessive genes for dwarfing, with additive effect, have so far been identified in this material.

Using the Norin dwarfing genes, the dwarf winter wheat variety, Gaines, was developed by Dr. O.A. Vogel in Washington State, U.S.A., in 1961. Similarly, dwarf spring wheat varieties had been developed in Mexico by Dr. N.E. Borlaug and co-workers. In order to develop dwarf wheat varieties suitable for cultivation in India, the Indian Agricultural Research Institute introduced in 1963 a large variety of wheat material containing the Norin dwarfing genes from Mexico, through the courtesy of the Rockefeller Foundation and the Mexican Ministry of Agriculture. In 1963 the I.A.R.I. distributed this material to several wheat breeding centres in order to assess the extent of their adaptation and reactions to the races of stem, leaf and stripe rusts prevalent in the country.

In addition to breeding material, bulk quantities use of commercial spring wheat varieties, Lerma Rojo 64A, Sonora 63, Sonora 64 and Mayo 64, were also obtained. These varieties were tested in all the wheat growing States of India during 1963-64 and 1964-65 under the All-India Coordinated Wheat Improvement Project. In addition, they were subjected to detailed physiological, pathological, chemical and agronomic tests at the I.A.R.I. On the basis of the data obtained two of these varieties, Lerma Rojo 64A and Sonora 64, were approved by the Central Variety Release Committee of the Indian Council of Agricultural Research in 1965 for cultivation in irrigated areas.

Lerma Rojo is a later variety with a high degree of resistance to all the three rusts. It performs very well under timely sown conditions and in areas characterised by stripe rust epidemics. Sonora 64, on the other hand, is an early variety and is well suited for growing in rotations like maize-wheat, potato-wheat, rice-wheat, sugarcane-wheat, etc. (See tables 1 and 2). It has two genes for dwarfing and hence is the most lodging-resistant variety so far released. Being early, it is a safe variety for cultivation

TABLE 1

Productivity per day in some wheat varieties

<i>Variety</i>	<i>Days in the field</i>	<i>Productivity (kg/ha/day)</i>
NP 880	151	17.1
Lerma Rojo	153	24.8
S 227	154	34.2 34.2
Sonora 64	133	42.5

under high fertility conditions in the eastern parts of Uttar Pradesh, Bihar, West

Bengal, Rajasthan, Madhya Pradesh, Gujarat, Maharashtra, Orissa and Madras. Sonora 64 does not do well if sown before the middle of November in areas where the normal sowing time is later October or early November. It is susceptible to stripe rust and hence has not been recommended for areas where this rust is epidemic.

New Dwarf Wheats

Varietal diversity as well as a rapid replacement of varieties are essential for sustaining high wheat yields over many seasons. From the advanced generation material received from Mexico in 1963, several selections such as S227, S307 and S308 have been found to perform very well in the Northern Plains of India. These strains have amber grains and a very high yield potential. The original material of S227 received from Mexico segregated for resistance to leaf rust and resistant selections were made. In national demonstrations in 1965-66 and 1966-67 the highest yields were obtained with S227, which yielded respectively 6,800 and 8200 kg per hectare in a farmer's field in the Delhi State. S307 is a derivative of a cross involving Lerma Rojo and the Japanese dwarf strain Norin 10-B. Seeds of S227, S307 and S308 were multiplied at Wellington, in the Nilgiri Hills, during the summers of 1966 and 1967 and these varieties were approved for general cultivation in 1967 and these varieties were approved for general cultivation in 1967. Brief descriptions of these new strains and the names given to them are given below.

Kalyan Sonar. A selection possessing resistance to leaf rust made from the population of S227 grown in 1963-64. Selections were made at the I.A.R.I., the Punjab Agricultural University, Ludhiana, and the U.P. Agricultural University, Pant Nagar. Kalyan Sonar is a strain with medium maturity,

amber grains, profuse tillering and a very high yield potential. It is derived from the cross, Penjamo 64 x Gabo 55. The chapatti and bread making properties are good and this strain is likely to become one of the most widely grown in the country. From the same cross, a variety named Sieto Cerros 66 has been released in Mexico and a strain named Mexipak 65 in Pakistan. In Mexico, a sister selection with red grains is being grown commercially under the name Super-X. The same sister selection is called Indus 66 in Pakistan and VI8 and PV18 in India. Thus, this cross has yielded many outstanding selections characterised by a high yield potential and wide adaptability.

Sonalika. A single gene dwarf derived from the Mexican cross (H 54-388-An) x (Y 154 x N 10 B) (L 52) (R). The original material was received under the number S305. The grains of this variety are bold and amber. It is resistant to all three rusts and does well both under timely sown and late sown conditions. This selection was made at the I.A.R.I.

Safed Lerma. Another single gene dwarf derived from the Mexican cross (Y 154 x N 10 B) (L 52) (R). Since it is homozygous back-crossed three to Lerma Rojo 64A, it resembles Lerma Rojo 64A very closely in height, pigmentation and other characters. The main difference lies in the white seed and hard nature of this strain, in contrast to the red and soft grain of Lerma Rojo 64A.

Chhoti Lerma. A white seeded, two gene dwarf derived from the Mexican cross (R 4 (Sib) x HUAR). It is highly resistant to lodging and has high degree of resistance to all three rusts.

Sharbati Sonora. The two gene dwarf wheat variety Sonora 64 introduced by the I.A.R.I. in 1963 has, as mentioned earlier, proved to be capable of yielding about 6,000 kg per hectare when grown properly.

However, the grain is red, and so fetches a slightly lower price in the grain market. The variety was subjected to mutation breeding in 1963 by Dr. G. Varughese and myself, and an amber grained mutant, isolated from gamma ray treated material, was approved for release by the Central Variety Release Committee in 1967, under

the name Sharbati Sonora. This variety resembles Sonora 64 in all respects except the quality and colour of the grain. Besides having bold and amber seeds, Sharbati Sonora was found to possess on an average 16.5 per cent protein in contrast to about 14 per cent in the parent strain.

TABLE 2

Wheat yield in rotations involving late sowing

<i>Location</i>	<i>Rotation</i>	<i>Wheat variety</i>	<i>Date sown</i>	<i>Yield (Q/ha)</i>
Delhi	Sorghum-wheat	Sonora 64	29.12.64	42.4
Jullundur	Potato-wheat	Sonora 64	2.1.66	40.9
		Lerma Rojo	2.1.66	34.4
		Sonora 64	15.1.66	36.2
Samastipur	Rice-wheat	Sonora 64	5.12.65	37.1
Darbhanga	Rice-wheat	Sonora 64	19.12.65	25.5
Shahbad	Rice-wheat	Sonora 64	29.12.65	23.2
Delhi	Rice-wheat	Sonora 64	4.12.65	55.3

1 Quintals per hectare. One quintal equals 100 kg.

TABLE 3

Effect of irrigation applied at different stages of dwarf wheat, Sonora 64

<i>Treatment</i>	<i>STAGES OF GROWTH</i>						<i>Total number of irrigations</i>	<i>Yield (Q/ha)</i>
	<i>Crown root</i>	<i>Late tillering</i>	<i>Jointing</i>	<i>Boot</i>	<i>Flowering</i>	<i>Dough</i>		
1	1	1	1	1	1	1	6	51.4
2	1	1	0	1	1	1	4	51.3
3	1	1	0	0	1	1	4	52.3
4	0	1	0	1	1	1	4	44.0
5	0	1	1	1	1	0	4	45.2
6	0	1	0	1	1	0	3	42.3

Critical difference at 5% = 5.9

1 indicates irrigation given.

0 indicates irrigation not given.

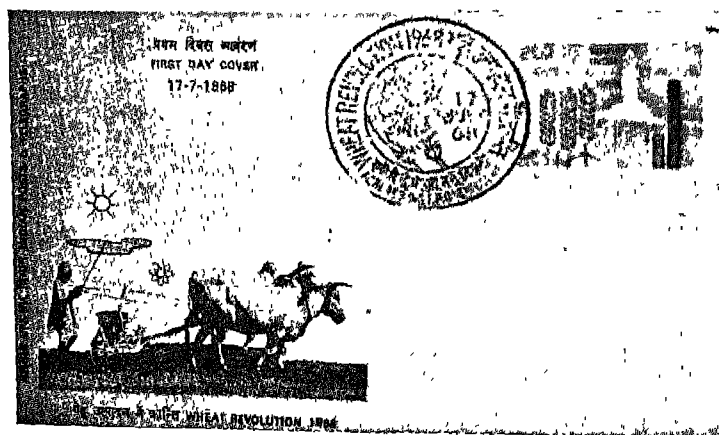
In addition, Shaibati Sonora has about 3 gm. lysine in 100 gm. protein, in contrast to only about 2 gm lysine per 100 gm. protein in Sonora 64. It appears that a major factory for protein and lysine synthesis may be located near the gene concerned with grain colour. This mutant has helped to disprove the idea that protein quality and quantity cannot be improved at the same time. Since Sharbati Sonora yields over 6,000 kg per hectare, it is also a symbol of the possibility of developing high yielding-cum-high quality varieties of cereals and other crops. This variety has also excellent bread making properties.

In the indo-gangetic alluvial soils lodging occurs even with single and two-gene dwarf strains. This is partly because of the poor soil structure arising from the many ploughings (usually exceeding ten) which farmers carry out before sowing wheat, and is partly due to the invariable occurrence of late rains and gales in March. Consequently, there is enormous interest now in varieties with three genes for dwarfing (called 'triple dwarfs') and several such strains are in advanced stages of testing. All the new varieties are non-lodging, highly resistant to the prevalent races of rusts, and have

brains with a high protein and lysine content.

New Agronomy

When the dwarf wheats were first tested extensively (in 1963-64) it became evident that certain fundamental changes in cultural practices were needed to get the best out of them. First, sowing had to be shallow (not deeper than 2 in), or the coleoptile could not penetrate the soil. Secondly, irrigation had to be given about 16 days after sowing, at the time of the initiation of the crown roots, otherwise the yield was considerably depressed. This is due to the synchronised nature of tiller development in these varieties, a factor which gets disturbed when irrigation is given late, as used to be done with the earlier tall varieties (see Table 3). The seed rate also had to be adjusted according to the tillering habit of the strain. When the wheat was sown in December or January, covering seeds with farmyard manure led to an increase in soil temperature and to a more rapid germination and growth. Sowing in a north-east to south-west direction resulted in the maximum interception of sunlight and promoted more vigorous growth.



India's 1968 wheat revolution commemorative stamp produced to mark the country's breakthrough in wheat production. The stamp depicts three stalks of wheat and the I.A.R.I. New Delhi, and includes a histogram comparing Indian wheat production in 1951 and 1962.

Thus, a considerable degree of sophistication in the agronomic practices and a greater attention to the qualitative aspects of the use of inputs became essential. What is most interesting and encouraging is that the Indian farmer has taken to all these practices with a zeal and speed which have baffled conventional economists and administrators.

Yields in Unirrigated Areas

The rapid spread of high yielding varieties in irrigated areas has widened the gap in the income potential of irrigated and unirrigated lands. Research aiming at increasing the yield of wheat and income of farmers in unirrigated and low rainfall areas has indicated certain practices which help in improving yields and production in such areas.

First, deep ploughing helps to conserve moisture and enables two crops a year to be

taken. Secondly, spraying which urea helps to increase yield by over 25 per cent in wheat. Scientist at the I.A.R.I. have found that over 30 per cent concentration of urea can be safely applied to wheat by breaking down the particle size of urea in a low volume sprayer. This has rendered aerial spraying of urea possible in moisture-deficit areas and this can be provided as a government service.

Since under conditions of low moisture tillering is very much reduced in wheat and barley, the yield has to come from the main tiller. I.A.R.I. physiologists have shown that by increasing the number of grains per ear in the main stem it is possible to increase the yield of wheat in dry areas. A special variety of wheat with branched ears like sorghum is therefore under development for dry areas. Also, hybrids between rye and wheat are under development which might combine high yield with nearly 20 per cent protein content.



A striking example of resistance to lodging. The two gene dwarf wheat on the left lodged after late rains in March, while the three-gene dwarf on the right side.

With the earlier tall varieties, about 3,000-4,000 kg per hectare was the upper limit of the yield that could be easily obtained in irrigated areas. With the introduction of the dwarf varieties, this upper limit has risen to 7,000-8,000 kg per hectare. The new varieties now in the breeder's assembly line at the I.A.R.I. belong to the following categories.

Triple dwarfs: These have three genes for dwarfing and will not lodge even under very adverse conditions. Triple dwarfs combining high yield, excellent grain quality and a high degree of resistance to rusts are now in the final stages of assessment and multiplication. *Rye and wheat hybrids:* These have very long ears and may yield well both in irrigated and dry areas. In addition rye wheat (Triticale) has nearly 20 per cent protein and a high lysine content.

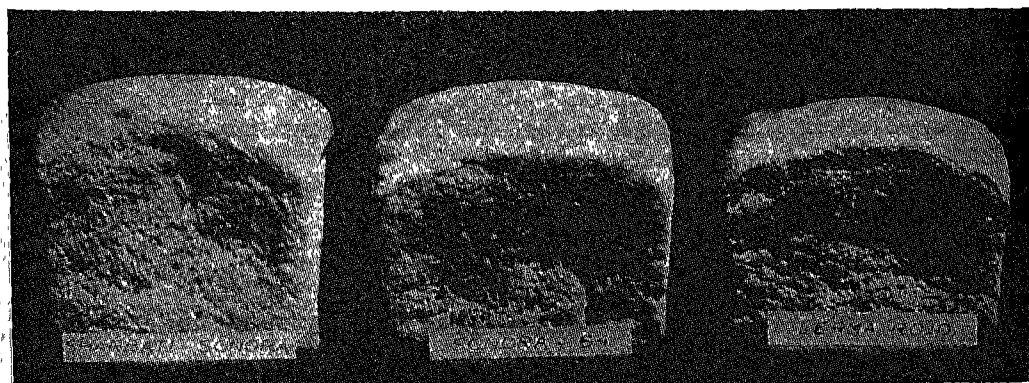
Hybrid wheat: As in maize, sorghum and pearl millet, research aiming to exploit the phenomenon of hybrid vigour is in progress in wheat. Such research was made possible by the discovery of male sterility in some wheat strains by Japanese workers

Branched wheat: A mutation for branching was induced in the variety NP 797 by gamma ray treatment. This has made the development of branched wheat varieties possible. Such varieties will have three to four times as many grains per ear as the varieties now grown and will greatly enhance the yield of wheat in both irrigated and dry areas. Branching is not known to occur in nature in bread wheats, but it occurs in one species of the wheat family identified in Egyptian mummies (*Triticum turgidum* var. *mirabile*).

Thus, in the immediate future, the prospects are bright for developing wheats which can yield about 10,000 kg per hectare.

Dwarf and high yielding varieties have been developed in *durum* (macaroni) wheat, which is cultivated extensively in Madhya Pradesh and Mysore.

India is frequently referred to abroad as a country in which research and extension function without proper coordination. While there is some basis for this comment, few people are aware that India today holds the world record for the speed with which a



Bread made from the same quality of flour from three different wheats to demonstrate variation in loaf volume

significant research finding has been applied in the field. During the winter 1963-64, the I.A.R.I. introduced wheat varieties containing the 'Norin' dwarfing gene from Mexico on the basis of the author's theory that dwarf varieties were essential for breaking down the barriers to high wheat yields. These were thoroughly tested all over the country during 1963-64 and 1964-65, and sufficient data to convince the Government of the wisdom of importing large quantities of seeds of two varieties were presented in June, 1965. That year 250 metric tons of

seeds were imported, and 18,000 metric tons in 1966. As a result, we had nearly 400,000 hectares under dwarf wheats during 1966-67 and about two million hectares during 1967-68. There is no parallel for such rapid spread of new varieties in the world, and this great achievement has stimulated Turkey and Pakistan to take similar action this year. The wheat harvest of 1967-68 is estimated at over 17 m. metric tons, in contrast to the seven million harvested in 1951-52, when the first Five Year Plan was initiated.

SUPPLEMENTARY READERS IN SCIENCE SERIES

The general aim of this series is to stimulate the interest of school children in the world of science and to keep them in touch with the more significant developments that are taking place in its various fields.

WEAPONS : OLD AND NEW

by

Mir Najabat Ali

Foolscap quarto, pp 76, 1967

Rs. 2.25

This fascinating little publication is a primer on weapons, both old and new. The book is attractively illustrated and describes interesting weapons such as the boomerang, the harpoon and even the South American bola. It talks of swords of many kinds, of guns and tanks and missiles, and takes the story right up to latest inventions of modern warfare

Enquiries :

Business Manager

Publication Unit

National Council of Educational Research and Training

71/1 Najafgarh Road

New Delhi 15

Study of Surfaces-II

Effects related to Surface Tension

L.D AHUJA

Department of Chemistry
Indian Institute of Technology
Hauz Khas, New Delhi

IN an earlier article (1) the surfaces of pure substances, whether liquids or solids was discussed. It should be interesting to find out as to what happens to the surface tension of, say, a liquid, —when another substance is added to it. Obviously, it will depend upon whether the substance added is a solid or a liquid; if solid, whether soluble or insoluble and if liquid whether completely miscible, partially miscible or completely immiscible

Let us first of all take the case of the addition of solids to a liquid. From the point of view of their effect on the surface tension, solids are divided into three categories.

- (a) non-electrolytes.
- (b) electrolytes.
- (c) polymers.

For the time being, the case of polymers may be left out. For categories (a) and (b), it has been found that whereas the addition of non-electrolytes decreases the surface tension of say water, addition of an electro-

lyte increases it, the effect is much more pronounced in case of decrease, than in the case of increase. For example, addition of 10^{-3} moles of sodium oleate decreases the surface tension of water from 72 dynes/cm at room temperature to a value of 25 dynes/cm, on the other hand a 5, molar solution of KCl has its surface tension value of only 80 dynes/cm. The fact that even small amounts of these nonelectrolytes like higher fatty acids and alcohols can reduce the surface tension so much, shows that they must be concentrating on the surface rather than dissolving in the bulk; while in case of electrolytes, the concentration in the bulk, is much more than the concentration on the surface.

In fact, by studying the change in surface tension of water, produced by the addition of a known amount of these higher fatty acids or alcohols, it is possible to find out the surface excess i.e. the difference between concentration in the surface and that in the bulk. On the basis of thermodynamics, Willard Gibbs that mathematical wizard and one of the best scientific genius of the 19th century, whose work lay unnoticed for 50 years before it was brought to light by Roozeboom, derived an equation for calculating the surface excess of the solute. His equation is

$$\Gamma = -\frac{C}{RT} \frac{d\gamma}{dc}$$

Where

Γ —denotes the surface excess

C—the concentration of the solution

$d\gamma$ —the change in surface tension by the

dc —corresponding change in concentration of solution.

R—the well-known gas constant

T—the temperature of the experiment.

For water and say stearic acid Γ comes out to be 10^{-10} moles/cm for a concentration of 10^{-3} moles/litre. Thus we have got a method of calculating concentrations, which

could not be easily determined by any of the chemical methods known at that time.

Coming to the addition of one liquid to another, you must have seen beautiful colour patterns when a drop of hair oil falls on the surface of water. It spreads in the form of a thin film with beautiful colour patterns. These thin films prevent the evaporation of water and are used in suppressing the evaporation of water from lakes and reservoirs in many tropical countries. The substance found to be most effective is cetyl alcohol, chemical name (hexa decanol $C_{16}H_{33}OH$). The technique is very simple. Cetyl alcohol is dissolved in a volatile solvent. Benzene was the first craze, but its place has now been taken by petroleum ether because of its lower boiling point and chemically more inert nature. The dilute solution is spread over the surface of water. The solvent soon evaporates leaving behind a compact monolayer of cetyl alcohol. Oil films are also used to calm down the seas near the shores.

You may ask as to why do these higher fatty alcohols or acids try to concentrate on the surface rather than distributing themselves in the bulk. The reason lies in their bifunctional character. Their molecules consist of two parts—the insoluble long chain hydrocarbon part and the soluble functional group. OH, COOH or COOR. Since the hydrocarbon part is not accepted by host molecules of water, where else can it go? And here it is helped by the hydrophilic group OH or COOH. In fact, the long chain molecule stands on the surface upside down with its head—the active group pointing towards water and the rest of the non-active molecule away from water.

From the maximum amount of material that can be spread so as to form a compact mono-layer i.e. when there occurs no further decrease in surface tension, we can find out the thickness of the monolayer and

from it calculate the length of c-c bond. The results obtained have been found to compare very well with those found from X-ray studies.

This tendency of substances to concentrate on the surface is called adsorption—a phenomenon having a great theoretical and practical importance.

I think a few words must be said about the various methods employed for the determination of surface tension of liquids. By far, the most common method used in many laboratories is the capillary rise method.

If the capillary tube is placed in a beaker containing mercury, we will see that in this capillary tube the level of mercury goes down rather than rising up, it also forms a convex surface rather than a concave one as is the case with water. The depression of the level of mercury in the capillary is due to the fact that the pressure at this point is greater than that at surface in the outer vessel.

The rise or fall of liquids in capillaries can also be explained in terms of forces of cohesion and forces of adhesion. Cohesion is the force of attraction between the molecules of the same substance and adhesion is the force of attraction between molecules of different substances. Water rises in the glass capillary, because the force of adhesion is greater than the force of cohesion. Mercury is depressed in the same capillary, because the force of cohesion is greater than that of adhesion. By similar reasoning, we can explain the spreading of one liquid on another or a liquid on a solid.

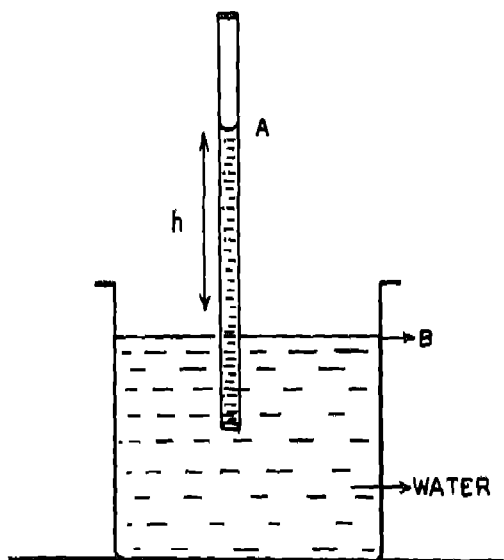
A column of the liquid is supported against the force of gravity by the force of surface tension which acts along the circumference of the tube.

Weight of the liquid column of height h = $h \cdot d \cdot g$. Force of surface tension = $2\pi r \gamma$

(assuming an angle of contact equal to zero) equating the two, we have

$$2\pi r \gamma = h \cdot dg$$

$$\therefore \gamma = \frac{h \cdot dg}{2\pi r}$$



The very fact that the liquid has risen by a height "h" shows that pressure at A must be less than pressure at B. Thus we see that whenever there is a curved surface in a liquid, there exists a pressure difference across it. Now if the pressure on a concave surface is less than that on a plane surface of the same liquid, converse must be true for the convex surface. We all know that tiny

droplets always assume a spherical surface because of the force of surface tension. Since the outer surface of a sphere is convex in shape, tiny droplets must be having a higher vapour pressure. Kelvin, (Lord Thompson) derived an equation relating the vapour pressure with the radius of curvature of the droplet. In its simple form the equation is

$$\Delta P = \frac{2\gamma}{r}$$

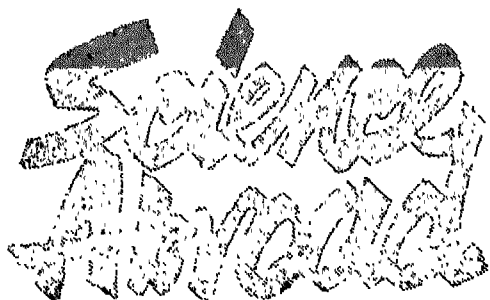
A drop falling from the tip of a pipette or a burette has a volume of approximately 0.05 CC which corresponds to a radius of about 0.2 mm and has a pressure of

$$P = \frac{2 \times 72}{2 \times 10^{-2}} = 72 \times 10^2 \text{ dyn/cm}^2$$

$$\Rightarrow 72 \times 10^{-4} \text{ atmospheres}$$

$$\Rightarrow 50 \text{ mm}$$

more than that of the liquid at the same temperature. For a drop of radius equal to 10^{-4} cm, the pressure difference comes out to be 1.44 atmosphere. Though thermodynamically the formation is necessary for the phenomena of condensation to occur. In the atmosphere the condensation occurs on tiny dust particles.



Elementary School Biology Revisited*

JOHN D. CUNNINGHAM
Keene State College, New Hampshire

IN the March 1966 issue of *The American Biology Teacher* appeared an earlier survey of the biological element in the current elementary school science projects (*New Developments in Elementary School Biology*, pp. 193-198). There has been much activity in this realm in most curriculum projects, here and abroad, and many new materials have become available, at least in preliminary editions, or are being tested. The aim of the present paper is to update the earlier survey, to which the reader is referred for further information.

Science Curriculum Improvement Study

The SCIS life science program takes advantage of the natural attraction of organisms to children by making living organisms the center of activity. Living plants and animals are brought into the classroom; and at times the children are taken out-of-doors to discover not only the amazing variety of organisms, but also how animals and plants interact with each other and with the soil, atmosphere, and the sun.

The focus of the program is the organism-environment relationship, and the over-all concept that has guided the development of the program is that of the ecosystem. The following quote from the trial unit *Organisms* expresses the point:

"By starting with an ecosystem, one can discover the whole of biology. This can be done by isolating one element after another—the living plants and animals; the physical factors such as light, water, temperature and soil, the interactions among the organisms, and between the organisms and the physical factors. One can study anatomy in relation to the role that any given organism plays in the ecosystem. One can study the food relations among organisms and arrive at the concept of a food chain. One can discover that animals excrete, that both animals and plants die, and that the excreta and dead remains of organisms are decomposed and become a part of the solid where they serve as nutrients for plant growth. One can study reproduction and its role of maintaining the population and heredity which maintains the type from generation to generation. One can study growth and development, the life cycles of organisms, and the various adaptations that fit particular organisms to particular environments.

The concept of the ecosystem can also lead to a study of evolution because changing physical conditions change the environment in which organisms live and create the situations in which the populations of organisms must either change or perish."

*Invited Paper, National Association of Biology Teachers, American Association for Advancement of Science, Washington, D C, December 29, 1966

During the 1966-67 school year, the first-grade trial unit *Organisms* is being tested. The ecosystem presented and analyzed is in the form of an aquarium. Observations result in questions, some originating from the children and some from the teacher. This first year program depends upon three key questions: (1) What is the stuff on the bottom of the aquarium? (2) Why did the water turn green? (3) What is the black stuff on the sand in the aquarium?

The beginnings for a large number of biological understandings are established as the children observe the aquaria during the year. Guppies are born and snail eggs appear, these young organisms grow, and death of some plants and animals occurs. The diversity of organisms and the concept of habitat are introduced as children observe various types of fresh and salt water aquaria. The idea of food chains is also introduced as *Daphnia* are observed consuming *Chlamydomonas* innoculated in the aquaria and are, in turn, consumed by the fish.

The controlled experiment is introduced as a way to obtain answers to questions. For example, the children might take two samples of "green water" from the same aquarium, place them side by side near a window, and add *Daphnia* to one but not the other. Within a few days the water with *Daphnia* becomes clear; the other remains green and opaque.

One of the problems in teaching biology, of course, is that living organisms follow their own schedule. While one can successfully anticipate some events, one cannot expect to plan and follow a rigid schedule. Rather, one must skip back and forth depending upon what happens in the aquaria and on the children's responses to these events. To overcome the indeterminacy, the teacher's guide for *Organisms* has a large chart that depicts the major expected events.

In the center is a drawing with arrows leading out of an aquarium to determine what part of the guide deals with the topic. While the order in which the major events are taken up is not considered important, it is suggested that each topic should be followed through to completion, although several topics may be dealt with concurrently.

The SCIS life science group is also engaged in an intensive study to determine a framework for the life science program in grades two through six. At the present time the following plan is being pursued. The second grade program will build on the concepts of the first year by comparing an aquarium containing organisms with one containing no organisms in order to demonstrate that organisms cause a change in their habitat. This experience, among others, is the beginning of the concept of ecosystem.

The children will also observe aphids on lentil *Eloidea* and pea plants. These observations will be used to enlarge the concepts of birth, growth, and decay, and lead to the concept of life cycle. The observations of aphids also permit the introduction of concept of population, primary food producers, herbivores, consumers, and community.

During the third year the investigation of the interactions within an ecosystem will be continued with a series of observations and experiments on the oxygen and carbon dioxide exchange between plants and animals. These experiments can be done with *Eloidea* and guppies within the familiar context of the fresh-water aquarium. The idea that physical factors function in an ecosystem is introduced by the observation that oxygen production in plants depends on light. It also opens by way to introduce the concepts of photosynthesis and the dependence of animals on plants for oxygen and food. Further observations and experiments will

demonstrate the operation of other physical factors such as temperature, moisture, and minerals.

During the fourth grade, the concept of life cycle begun in the second grade will serve as starting point for consideration of reproduction and heredity. This will necessitate the introduction of the cell concept, the use of simple microscopes, and breeding experiments with *Drosophila*. The relation of reproduction and heredity to the survival of populations will be stressed.

In addition, there are also biological aspects to other units. For example, in the first-grade unit *Material objects* are lessons designed to give children an opportunity to describe the properties of plants and animals, to note similarities and differences among plants, to recognize some relationships between animals and their environments, and to think of plants as objects.

In the second-grade unit *Variation and Measurement*, many of the ideas of the section on variation are conveyed using biological examples. For example, children study variation in seeds, variation in the number of peas (or other seeds) in pods, and variation in compound leaves. Children learn the techniques of constructing histograms in order to depict the variation observed and to use the information to make predictions.

Elementary Science Study

ESS units are designed as much to extend the child's skills of scientific inquiry as they are to exhibit particular scientific concepts. A number of the biologically oriented units are briefly described below. Many of the units have films and film loops designed to be an integral part of the study.

Behavior of Mealworms: This unit, rested with children from the third to the eighth grades, is designed to stimulate children to

ask questions about the observed behavior of an unfamiliar animal. Some of the activities are: making a mealworm back up, how mealworms explore a box, how mealworms follow walls, how mealworms find bran, how mealworms know they are under brain, etc. Several booklets are being developed for use in conjunction with the unit. One is entitled *How Does the Moth Get Out?*, a series of observation on the use of an ingenious chemical mechanisms by the Chinese oak silk moth in escaping from its cocoon. Another is *Owls*, describing research on how owls locate their prey by homing on the sounds produced by the prey.

Bones: This unit is designed for children in grades four through six. Children become familiar with the variety of bones, note the similarities and differences among them, assemble skeletons, etc. Two student booklets accompany the unit, *How to Make A Chicken Skeleton* and the *Bone Picture Book*.

Small Things: An Introduction to the Microscopic World.

In this upper elementary unit, children are introduced to the microscopic world and to the instruments needed to make it accessible. Children compare onion cells with human cells, learn staining techniques, search for life in pond water, and compare cells from miscellaneous parts of organisms and non-living objects. Accompanying the unit is *The Faithful Eye of Robert Hooke*, quotations and illustrations from Hooke's *Micrographia* which suggest to the children microscopic investigations which they may undertake themselves.

Microgardening: The study of molds constitutes the subject matter of this unit for children in grades four through seven. Considerable effort and ingenuity was necessary to reduce the relatively high cost and time-consuming preparation required. Titles

of areas studied are "What Are Molds?" (three activities, 7-10 days), "What Influences the Growth of Molds?" (four activities, 4-5 week) "Where Do Molds Come From?" (five activities, 4-5 weeks), "What Can Molds Do" (three activities, 3-4 weeks), and "What Influences the Rate of Mold Growth?" (two activities, 2-3 weeks). Two books accompany the unit, the *Illustrated Handbook of Some Common Molds* and *The Microgardening Cookbook*.

Growing Seeds: In this unit, children in grades K-3 plant a collection of seeds and non-seeds to see which ones grow. The internal anatomy of seeds is investigated and children keep track of plant growth by cutting strips of paper daily showing the height of their plants.

Changes. Children in the early elementary grades investigate changes that take place in objects left in different environments. Thus from the biological standpoint, food may become moldy or decompose, maggots, may appear, organisms may lose water, etc.

Desert Animals: This is a primary unit on the adaptations of desert mammals (gerbils and kangaroo rats) and lizards. *Curious Gerbils* is a children's book on the management of gerbils and suggests experiments they can conduct concerning its diet, behaviour, etc.

Pond Water: Both the microscopic and macroscopic plants and animals found in fresh-water ponds are studied in this unit. The unit *Duckweed* may be studied as an outgrowth of *Pond Water*. The duckweed is large enough to be studied without magnification yet small enough to reproduce and grow rapidly and to respond well to varying environmental conditions.

A number of units involve the study of the life cycles of particular organisms and the effect on their development or behaviour of such environmental variables as light, water,

temperature, etc. This is true of units entitled *Mosquito larvae*, *Butterflies*, *Brine shrimp*, *Frog eggs and Tadpoles*, and *Euglena*. Other units, while not concentrating so much upon life cycles, deal with the interactions of the organism and various environments. In this category would be such units as *Earth-worms*, *Crayfish*, and *Marine life*.

Two units deal primarily with plants. *Budding Twigs* (sixth grade) studies the effect of position of bud, length of twig, water, light, temperature, etc. on budding. *Bending Plants* (grades 4-6) concentrates on responses of oat seedlings to light and gravity.

American Association for the Advancement of Science

Under the direction of its Commission on Science Education, the AAAS has prepared a K-6 program entitled *Science—A Process Approach*. The AAAS program takes the view that the procedures of scientific enquiry, learned not as a can on of rules but as ways of finding answers, can be applied without limit. The processes chosen for the primary grades are: observing, classifying, using space time relations, using numbers, communicating, measuring, inferring, and predicting. Those added in the intermediate grades are: formulating hypotheses, controlling variables, interpreting data, defining operationally, formulating models, and experimentation.

The books start with one A for the beginning of kindergarten and end with Seven B for the later part of the sixth grade. Titles of predominantly biological lessons, and the appropriate process label, in each book are given below:

- One A —Classifying 1. Classification using leaves or nuts
- Observing 6. Perception of Odor

- One B —Observing 7: Observing Animals
—Classification A: Classification Using Shells
- Two A —Using Space/Time Relations 7: The Shapes of Animals
—Observing 12: Observation of Color and Color Change in Plants
—Observing 13: Observing Mold Gardens
- Two B —Observing 14: Seeds and Seeds Germination
—Classifying B: Classification Using An Aquarium
—Communicating A: Describing the Changes in a Sensitive Plant
- Three A —Classifying 5: Kinds of Living Things in an Aquarium
—Observing 16: Observing Animal Motion
—Observing 17: Bacteria
- Three B —Observing 18: Five Plants
- Four A —Inferring 5: Tracks and Traces
—Observing 20: Observing Growth in Plants
—Predicting 4: Interpreting the Field of Vision
- Four B —Observing 21: Growth from Parts of Plants
—Communicating 11: Graphing Experimental Results with time as a Variable.
—Observing 22: Observing Some Animal Responses to Stimuli
—Inferring 7: Loss of Water from Plants
- Five A —Controlling Variables 1: Growth of Mold on Bread
—Interpreting Data 1: Guinea Pig Learning in a Maze
—Controlling Variables 3: Loss of Moisture from Potatoes
- Five B —Controlling Variables 7: Orientation of Plants
- Six A —Defining Operationally 4: Defining Root, Stem, Leaf, and Fruit
—Controlling Variables 9: Forgetting and Relearning
- Six B —Interpreting Data 9: Levers in Physical and Biological Systems
—Interpreting Data 10: Variation in a Biological Population
—Interpreting Data 13: Measuring Small Things
—Controlling Variables 11: Brine Shrimp
—Controlling Variables A: Responses of *Daphnia*

- Seven A —Experimenting 3: Semipermeable Membranes
—Formulating Models 4: A Mechanical Model of a Semipermeable Membrane System
—Formulating Models 5: The Growth of a Simple Population
—Experimenting 4: Living Things Give off Carbon Dioxide
—Controlling Variables 12: Human Reaction Time
- Seven B —Formulating models 8: Life Cycles
—Interpreting Data 14: Growing Plants in Various Colors of Light
—Experimenting 6: Chromatography
—Interpreting Data 15: Human Characteristics
—Experimenting 7: Photosynthesis
—Controlling Variables 14: Fermentation
—Interpreting Data 13: Chick Embryo
—Controlling Variables 14: The effect of Egg Position on the Chick Embryo

Minnesota School Mathematics and Science Teaching Project

At least for the early elementary grades (K-4), MINNEMAST is not developing biology as a separate subject. Rather, where experiences of a biological nature are appropriate to the aims of a particular unit, the experiences are provided. *A Living Things Handbook* is also being developed to encourage and assist the elementary teacher in exposing her children to living things in the classroom and in the field.

MINNEMAST materials currently available for distribution are at the kindergarten, first, and second—grade levels. Units for the third and fourth grades are under development or are being tested. Representative biological lessons from selected units are briefly discussed below.

Watching and Wondering (K.1). This initial kindergarten unit contains some biological possibilities as children explore, for example, the outdoor area of the school grounds.

Describing and Classifying (K.2). This unit is an introduction to describing the properties of objects and building a classification scheme based upon the observations. Some of the objects studied are biological. Thus, in Lesson 3, children classify leaves and seeds, classify in terms of living and non-living, and classify animals by the way they move.

Our Senses (K.3) Although the emphasis is on the human senses of sight, hearing, smell taste, and touch, the unit serves as a basis for understanding how animals in general become aware of the environment. In the kindergarten series, the unit is closely related to K.2 in that an object is what it is perceived to be and that perception comes through the senses.

Shape and Symmetry (K.4). From the biological standpoint, the most important part of this unit is the symmetry section. Children are given experience with bilateral symmetry (e.g. butterfly), rotational symmetry (echinoderms), and translational symmetry (millipede).

Objects and Their Properties (1.1) The introductory lesson in this first-grade unit is entitled "Animals as Objects." In the lesson, the behavior of an animal is considered to be just as important as the description of its size, color, shape, or surface characteristics. Other lessons of biological interest are "Ants" (Lesson 3) and "Grouping Objects by Two Properties" (Lesson 6).

Changing and Unchanging Properties (1.2) In this unit the children's attention is focused on a number of "before" and "after" situations, both in terms of the obvious changes that occurred and on the properties that did changes. This introduction to the idea that an object can change in some of its properties and remain unchanged in others will bridge the gap between a static world of description and the dynamic world of interactions.

Children discover that although living organisms change continuously, they retain a biological identity. The organism investigated are a simple plant, a lepidopteran, and the child himself.

Investigating Systems (1.6). Lesson 5, lasting for four days, is entitled "Systems for Eating" and introduces children to a system within living objects. They identify the parts of the body involved in taking in and chewing food, both in humans and in other animals. Prior to this the children had been studying inanimate systems where it was feasible for them to remove and replaces this or that object in the system to note the effect. Because this cannot be done by children with living systems, models of animals jaws and teeth (flat stones representing chewing teeth and knives representing biting teeth) are used.

Scaling and Representation (2.2) The last two lessons in this unit are entitled "To What Scale Do Parts of Our Bodies Increase in Length?" and "Do Parts of a Plant Increase in Length to the Same Scale?" In these lessons, children determine which parts of the human body and plants increase most and least in length in time.

Discovering Systems. This is a third-grade unit under development and therefore tentative. The biological content of the unit includes (1) systems by which animals move, and (2) systems by which water circulates through plants. In connection with the former aspect, children study fin motion in swimming fish, wing movement in flying birds, and leg action in terrestrial vertebrates. The second portion of the unit begins with children investigating where water comes from on the inside of a plastic bag securely tied over a potted plant, leads to the examination of stomates, root action, and leaf venation, and ends with studies of water deprivation and the calculation of

water content of leaves.

Elementary School Science Project (University of California)

Four biological units have become available in published form during the past year. One of these is Part II of the series *What Am I? A Unit of Human Physiology* entitled *How I move*. (Part I was entitled *How I began* and included comparative studies of human and chick embryology.)

How I Move is a study of the skeletal-muscular system of the human body. Part I of the unit introduces children to the nature and function of muscles and to their relation to bones and nerves. After a discussion of movement, the following topics are taken up: muscle contractibility, types of muscle tissue and their differentiation from other tissues, muscle metabolism, the difference between voluntary and involuntary muscle action, and the role of the nervous system in muscle action.

Part II of the unit includes the skeletal system. Beginning with the concept of the skeleton as a framework, the activities bring out the function of the skeleton in body movement, its role in determining the shape of the body and as a protector of vital organs, and its need for calcium compounds in order to remain stiff and strong.

Both *How I Began* and *How I Move* are designed to be part of the first, second, and third-grade science program. A third unit projected for the *What Am I?* Series is entitled *How I Know*. In this unit children will investigate some of the ways in which they become aware of their external environment and how they are able to make the necessary body adjustments in order to exist and to protect themselves within that environment. The suggested grade placement for this unit is the third or fourth grade. A projected fourth unit in the series,

designed for the fifth and sixth grade, is *How I Keep Alive*, a study of metabolism.

Animal Coloration. An Introduction to Natural Selection is another ESSP unit, designed for grades 4, 5, or 6. The unit chose coloration because it is an adaptive attribute of animals that is easily observed. Although natural selection is introduced by considering how coloration may have developed, it is not expected that most children will gain much understanding of the process yet. Various lessons, some utilizing living organisms and others using models, deal with such topics as functions of color, high-light and shadow, countershading, disruptive coloration, concealment of give-away parts, shadow concealment, the vision of animals, and advertising coloration. Because of the nature of many aspects of the topic, a number of lessons are vicarious experiences in the classroom rather than field work with live organisms.

Botany for Beginners in Science is a study of the morphology of the Angiospermae for the early elementary grades. Lessons, in the order of their appearance, are as follows: Finding Out About Living Things; Dormant Seeds; Germinating Seeds; Structure and Relation of Parts of a Flowering Plant; The Leaf and Its Parts; Venation Patterns and Shapes of Leaf Blades; Base, Tips, and Margins of Leaves; The Stem; The Role of the Bud in Growth and Differentiation of Plants; Variations of stems; The Herbaceous Stem (Asparagus); Some Horizontal Stems; Underground Stems; External Features of a Woody Stem; The Root; The Generalized Flower and its Longitudinal Mapping; Mapping the Ground Plant of a Flower; Flowers Pollination; The Arrangement of the Flower on the stem; Inflorescence; Fruits and Seeds; The Seed Needs Moisture to Start Growth and, How Seeds Travel.

Stories of fossils has been tested in grades 2 through 6. Basically, the Unit consists of a series of stories, each approximately 20 minutes in length that can be read to children and discussed. Representative titles are "Folsom Man: The Bison Hunters," "Ancient Deep Freeze," "The Tar Pits at Rancho La Brea in Los Angeles," "Dr. Leakey Finds a Very Old Fossil Man," "Deserts Were Not Always Deserts," etc. There are four appendices entitled "Experiments," "Your school Museum Collecting Specimens of Fossils," "Skeletons and Other Demonstration Materials, and "Summer Trips."

School Science Curricular Project

Most of the units of the SSCP will be available later in the 1966-67 school year as it completes its work. Two items of interest to biologists are now available in trial form. One is not a teaching unit but is entitled *Construction of Fifty-Gallon and Thirty-Gallon Aquariums*. Plans are presented for the construction of large, low-cost aquaria that most schools could not otherwise afford. The fronts are clear glass but the sides, backs, and bottoms are constructed of waterproof plywood with leakproof joints.

Another unit, entitled *Beans and Biology*, contains three ideas that form the basis of the sequence of lessons science as a process of inquiry, measurement as a very useful investigative tool, and such broadly applicable biological concepts as the effect of temperature, soil, water, light, air, and reserve food upon seed germination. In addition to the eleven teaching lessons in the Unit are six Teacher Guides, including background papers on seeds and on quantitative methods, time table of activities, list of materials and equipment, construction details for such equipment as screens for

sorting beans according to size, constant temperature chamber, drying apparatus, etc., bibliography, and glossary. In common with units from some of the other projects is an emphasis upon measurement and the introduction of statistical and graphing techniques useful in interpreting data.

Another unit, *Time, Space, and Species*, deals with the ideas of evolution, genetics, and classification. Included is a game of Nimsects which serves to introduce some of the basic concepts of genetics. Students are equipped with a set of cards which, when assembled, form a mythical organism, the Nimsect (which looks like an insect). The character of the Nimsect, type of legs, wings, etc., is determined by "genetic information" carried on IBM cards.

Still another unit, without a formal title at this stage, deals with feedback control, with homeostasis being the prime biological example.

Webster Institute of Mathematics, Science and Arts

During the fall of 1966, WIMSA released *On the Fly*, the first of four documents on the house fly. *Even Flies Remember*, an informal approach to heredity and genetics; *Bringing the Mountain to Mohammed*, *The Continuous Laboratory Approach* are the other works. *On the Fly* was originally developed with fourth and fifth graders.

The house fly was because, among other things, almost everything it does may be easily observed if it is housed in a proper cage. The fly spends its entire adult life in the open, feeding, breeding, egg-laying, and dying. He is large enough to watch easily, yet small enough to make the task of culturing him SIMPLE. The Teacher's guide is not offered as the "true" pathway to a child's understanding of biology but only as a source of husbandry and relevant

technical data and as a report of significant anecdotes and selected experiments; it is not a course of study.

Although one could begin with any stage, the pupae is selected as the starting point because they neither wiggle away or fly away. A one gallon jar will house 60-70 flies conveniently. A base with small sides makes a convenient support and a large rubber band can hold the jar has three one-inch holes to hold souffle cups containing food, water, culture media, or eggs. A sleeve (cheese-cloth, discarded man's shirt sleeve or woman's stocking, etc.) over the opening allows easy access to the interior without the escape of flies.

In many classrooms this method of rearing flies, although efficient, might prove to be impractical due to the quantity of larval medium required and the disposal problems. In these circumstances a Petri plate can be utilized to good advantage. It also makes it easy to test different environmental conditions such as temperature, light gravity etc.

Elementary School Science Project

(Utah State University)

In connection with their fall 1964 teacher's manual entitled *Science for First Grade*, the ESSP distributed a "Biological Supplement." These materials contained, following introductory material, four units entitled "Observing," "Classification," "Growing Plants," and "Microscopic Life". Feeling that the old biological supplement failed to reflect the rationale and purposes to which the ESSP was committed, the group completely revised the material and now makes available, on an experimental basis, a new biological supplement for use with *Science for First Grade*.

The new Unit I, entitled "Observing," now includes sections on General Environ-

ment, classifying Aquatic Environment, and Terrestrial Environment. Unit II, entitled "cages," includes Observing Bees, Observing Ants, Measuring Plant Growth, and Measuring Amphibians.

African Primary Science Programme

(Educational Services Incorporated)

The APSP is currently building upon ESI's experience in Africa with mathematics materials. Two summer writing conferences have been held in Africa (Entebbe and Dar es Salaam), several science education centers have been established in African countries, and numerous trial units are being tested in African schools. In all these units it has been necessary to come to grips with the lack of science equipment. Thus, butterfly cages are improvised from bamboo and mosquito netting, electrical switches from bottle caps, and hand tools from hardened floor nails. Children use water-drop lenses to view objects closely.

A brief description of some of the trial units produced during the 1966 summer conference in Tanzania follows. As will be seen, many of them are adaptations of units from U.S. curriculum efforts, particularly ESI's own Elementary Science Study.

Buds and Twigs. These studies begin by children deciding whether a stripped twig is dead. They plant various twigs ("right side up" and upside down") and eventually get into elementary plant physiology experiments. Gradually the studies extend to buds, flowers, apical dominance, and grafting.

The Fly Cycle. This is primarily an African adaptation of the WIMSA unit on the Fly.

Ant Lions. Those familiar with the ESS unit *Behavior of Mealworms* will see many similarities in this unit. Basically, it uses the ant lion to teach many of the things being taught in this country with *Tenebrio*.

Thus, the children try different kinds of food, various materials, find out how quickly the ant lion finds a pile of sand, work on questions such as "Can the ant lion see?" and "Will the ant lion follow a trail of sand?" etc.

Chicks in the Classroom. These studies are similar to those contained in the University of California Elementary School Science Project unit *What Am I? How I Began*.

School Mathematics Study Group

Although not an elementary school science project, SMSG has recently released booklets entitled *Mathematics and Living Things* Designed for use in the Junior High School, a number of the activities nevertheless have potential for inclusion in elementary school science curricula. Some of the lessons are as follows: variation in

leaves, measurement of leaves, ratio of length and width, paper chromatography, variation in humans, calculation of leaf surface area, relationships between leaf surface area and water loss, counting stomates, muscle fatigue, exercise and pulse rate, yeast metabolism, growth of molds, size of cells and metabolism comparison of surface area and volume in organisms, volume of plants and plant parts (such as a cone), etc.

Throughout all these activities, such mathematical concepts as the following are stressed: units, significant figures, ratio, graphing, greatest possible error, simple closed curves, scientific notation, percent, measures of central tendency, construction of histograms, interpolation and extrapolation, curve fitting, coordinates, solid geometry, indirect measurement, area, volume etc.

APPENDIX

Science Curriculum Improvement Study (SCIS), Department of Physics, University of California, Berkeley, California 94720

Elementary Science Study (ESS), Educational Services Incorporated, 55 Chapel St., Newton, Massachusetts 02160

Science—A Process Approach, American Association for the Advancement of Science (AAAS), Commission on Science Education, 1515 Massachusetts Avenue, N.W., Washington, DC, 20005

Minnesota School Mathematics and Science Teaching Project (MINNEMAST), 721 Washington, Ave., S.E., Minneapolis, Minnesota 55414

Elementary School Science Project (ESSP), University of California, 2232 Piedmont Avenue Berkeley, California 94720

School Science Curriculum Project (SSCP), University of Illinois, 805 West Pennsylvania Avenue, Urbana, Illinois 61801

Webster Institute of Mathematics, Science and Arts (WIMSA), Webster College, Webster Groves, Missouri 63119

African Primary Science Program (APSP), Educational Services Incorporated, 55 Chapel Street, Newton, Massachusetts 02160

Elementary School Science Project (ESSP), Department of Physics, Utah State University, Logan, Utah 84321

School Mathematics Study Group (SMSG), Cedar Hall, Stanford University, Stanford, California 94305

A Broad Outlook for Plastics

J. H. Cowie, Dept. of Chemistry
University of Essex

TWENTY-five years ago this would have sounded like the beginning of a science fiction novel but today it reads like a heavy-handed, over technical, commercial advertisement for the polymer industry. If one pauses to consider the variety of objects used and encountered daily, which are either man-made or naturally occurring polymeric materials, it soon becomes obvious that the opening science could be expanded into a catalogue far exceeding the length of this article.

The growth of the polymer industry in the last thirty years has been dramatic; in Britain alone the annual production of synthetic polymers is now estimated at well over a million tons and this is only a part of the total world production. The number of scientific journals used to disseminate the information gained by fundamental research has increased five-fold in the last decade and the polymer scientist is faced with an accumulation of knowledge the assimilation of which is daunting at the very least. In this time, too, polymer science has been maturing and the public idea of plastics as "nasty and cheap" has been eroded and changed by a rapidly developing technology which no longer produces substitutes but the necessary and sought after primary raw material.

Not every polymer created in the laboratory is commercially useful and indus-

try tends to concentrate mainly (though not entirely) on the so-called "bread and butter" materials, such as the polyolefins, acrylics, and polyesters. But the fields of application are now so numerous and the uses so diversified that one can never afford to discard a polymer whose potential has not been thoroughly investigated. The invasion of the home, and indeed all aspects of modern living, by man-made fibres and plastics is now taken for granted, but there are other areas where the use of polymers may not as yet be so obvious. The immense flexibility of polymers in modern science and technology [can best be illustrated, albeit inadequately by a few random examples.

As one endures the frequently damp British summer, it is hardly likely that thoughts of drought and water shortage are liable to spring often to mind, but the same cannot be said for residents in some other parts of the world. Add to this the more modern nuisance of water pollution, and it is immediately obvious that there will be a desperate need for pure water in the foreseeable future and to ignore the problem now could prove disastrous. With this in mind the use of polymer films and membranes in the desalination of seawater and purification of river water contaminated by industrial waste, is being studied intensively. Although the detailed mechanism of this purification process—known as reverse osmosis—is not yet clearly understood, in simple terms it can be considered to be an ultrafiltration in which the salt water is held, under pressure, against a membrane such as cellulose acetate. Controlled heat treatment of the membrane alters its semipermeability characteristic until a state is reached in which the membrane allows water but not the salt ions.

to pass through. Thus, if the osmotic pressure of the solution is exceeded by the applied pressure, fresh water flows through leaving an increasingly concentrated salt solution behind. By the introduction of a flow system, commercially viable units can be constructed and are being tested at present.

The sea, as well as being a possible source of fresh water, may also cover areas of the Earth containing a wealth of natural resources. Exploration of the seabed has already begun and it has been proved possible for man to live and work under water for short periods of time. It is conceivable that polymer membranes could play an important role in extending man's ability to exist under water. Ultra-thin silicone rubber membranes have been developed which act like a synthetic fish gill. An experiment has been carried out in which a bird cage was covered with one of these membranes. A canary was then put in the covered cage and immersed in a fish tank. The polymeric network which is impermeable to water allowed the oxygen dissolved in the water to pass rapidly through into the cage, thereby ensuring the bird's survival. The carbon dioxide breathed out likewise diffused through the membrane in the opposite direction and dissolved in the water. In this manner non-aquatic life can be supported under water and developments along similar lines may eventually allow human beings to live in this environment.

It has also been suggested that films with similar characteristics could act as oxygen tents for sickbeds by allowing the preferential accumulation of an oxygen enriched atmosphere around the patient without the need for auxiliary equipment. Although this technique has not yet been perfected, medical science makes good use

of some of these chemically inert and pliable polymers, which have been successfully utilised for various things such as artificial eye corneas, heart valves and replacement cartilage in ear and nose surgery. Application of polymer membranes in artificial kidney machines to remove minerals and urea from the blood stream while retaining blood protein and red cells, is reminiscent of their use in water purification, and illustrates that a particular property of a polymer may be exploited in a variety of ways. Attempts have also been made to create an artificial heart from silicone rubber but this has been only partially successful. It has been possible, however, to repair a damaged heart septum by means of a Teflon patch. This plastic has also made possible the regular use of kidney machines, where continual tapping of the patient's blood stream eventually becomes impractical. It was found that as the inert character of Teflon permits it to remain in the body without rejection, tubes could be inserted and left in the patient's arm to provide a connecting point for the machine this allowing its use on the regular weekly basis as required.

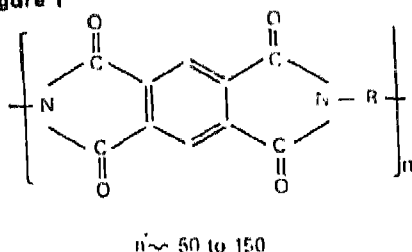
Many other applications are being explored. Hydrophilic gels are being used to make contact lenses, and without doubt the full potential of polymer materials in this field has not yet been realised.

Only recently it was generally thought that few new polymers of commercial interest would be developed, but requirements change and engineers and designers are constantly searching for materials with special properties which satisfy specific needs. For example, the strength and heat resistance of carbon fibre composites developed recently has led to their being used in sophisticated aircraft engines till now though impossible. Contrary to expecta-

tions, important new types of polymers have emerged, especially those exhibiting attractive mechanical and electrical properties over extremes of temperature.

The polyimides (Figure 1) provide examples of the most promising of these new

Figure 1

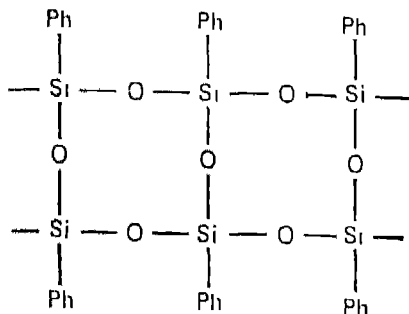


groups, and some members are capable of withstanding a temperature range of -250° to 400°C . The combination of thermal stability high modulus and excellent creep resistance and the retention of their electrical properties over such a wide range of temperatures has made polyimides essential vehicles and as fuel seals in jet engines.

Most common polymers normally consist of long single chains of identical units linked together, but it has been discovered that thermal stability can also be increased by the synthesis of "ladder polymers" in which the molecule is composed of two chains joined at regular intervals by covalent bounds. The polyphenyl silsesquioxanes (Figure 2) are good examples of this structural type and have been found to be stable in air up to 525°C . Polyaromatic heterocycles are also being developed with excellent thermal and electrical properties and one member in particular, polybenzoxazone, has an estimated life time of 10 years at 250°C .

It is quite obvious that there will be a continuing and growing demand, by all branches of industry for polymeric materials

Figure 2

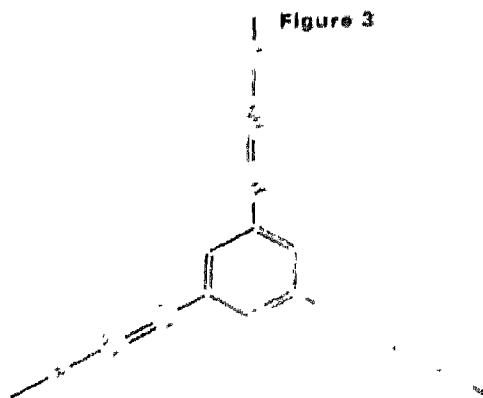


with specific properties and the increasing diversification of application poses problems. Constant discoveries by the laboratory worker can lead him across the paths of unrelated disciplines and creates the need for scientists with the ability to translate, the rapidly accumulating knowledge of the laboratory to medical and industrial application.

This information explosion in polymer science although gratifying to anyone with interests in the field, brings its attendant dilemmas not the least of which is the necessity for the academic research worker to specialise to an increasing degree. In doing so he is in danger of losing sight of the unified picture of polymer science. Communication is essential. The ingenuity of the synthetic chemist must be closely allied with the polymer physicist and physical chemist who can define material properties; finally, possible application must be recognised and developed. In the academic world the chain of events can be long, each link may be forged separately and often at great distances via the medium of the scientific literature and the time factor is extended accordingly. Industry cannot always be expected to bear the complete burden of research and development and in any case it may not have employees with the necessary breadth of outlook.

One way to overcome this problem is to form a group of scientists drawn from different disciplines and channel their varied experience towards a central problem. In the University of Essex a polymer consortium has been formed consisting of six chemists, five physicists, five electronics scientists, five mathematicians, and two computer scientists. The aim of the group is to cultivate interdisciplinary research and postgraduate training in the broadest sense, and it is hoped that the type of experience offered to graduates will better equip them to meet the challenge of the variety of problems with which they will be confronted in a modern technological society. By training polymer scientists in a co-operative atmosphere where the combined talents and different view-points of research workers, already expert in their particular field, can be brought to bear on a single unifying theme, one may expect to instil in a graduate a wider grasp of the subject and the capability of viewing his subsequent work in a more extensive manner. To achieve this end, multidisciplinary interlocking of many of the proposed research programmes is intended. For example, a study of the electrical conductivity of network conjugated polymers is to be initiated. Schiff's bases (Figure 3) prepared by the polycondensation of 1, 3, 5 triformyl benzene and various polyfunctional amines will be prepared by the synthetic chemists; the next step will be to study the physico-chemical properties of these polymers which physical chemists will do. The physicists will then continue by investigating the electrical properties which in turn will be tested for their technical potential by the electronic engineers. Meanwhile, mathematical and instrumentation research will be applied to the investigation of the fundamental aspects of the polymerization process,

which will enable controlled preparation of the materials to be achieved.



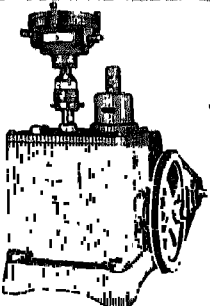

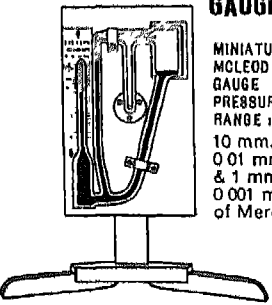
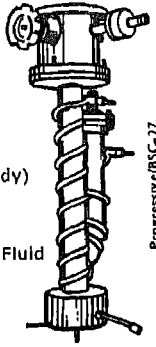
Other projects are also planned. No polymeric membranes of the general type mentioned earlier are to be investigated, cross-linked networks and gels will be prepared and examined. Fundamental studies on polymer structure in relation to properties are being carried out, which may contribute to the ultimate goal of defining criteria for the tailoring of polymer molecules with specific and predictable characteristics. The integration and application of computers for high-speed data processing is an essential part of the general programme and the correlation and interpretation of these data is being studied.

There is perhaps no single complete answer to the problems of an expanding science, but surely modern research requires the integrated team-work of specialists. Since it is too much to expect every individual scientist to cope adequately with the whole polymer field, co-operative group thinking must be fostered; indeed the consortium concept in universities may eventually contribute more widely to the requirements of

modern science and technology.

To launch the project the Science Research Council have awarded the consortium a grant of £ 51 792 over a period of three years and industry is also contribut-

ing financially. Of course, the research programmes are only in their early stages and it will be several years before the results of this method of working can be adequately judged.

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Promoting Teaching by Machine

BRYNMOR JONES

Vice-Chancellor of Hull University and
Chairman of Britain's National Council
of Educational Technology.

THERE is a widespread feeling in Britain—and not only in Britain that the technological revolution of our time and the closely related developments in communication present educationalists with unique opportunities to improve both the quality of teaching and the ease of learning.

Realising the potential of modern media and aids, such as television, film and programmed instruction, the University Grants Committee, the Department of Education and Science and the Scottish Education Department set up a Special Committee in the spring of 1963 "to survey the current use of audio-visual aids in teaching and research in the pure and applied sciences in institutions of higher education in Britain and, taking into account their use in similar fields in comparable institutions in selected countries overseas, to assess their potential usefulness and possible lines of development in Britain.

After considering and sifting all the evidence, the Committee's attitude to the

By courtesy: British Information Service.

value and importance of current audio-visual media and aids was expressed in their report in these words - "It is difficult not to believe that the communication of ideas can be greatly helped by the use of audio-visual aids. A mode of communication which makes both an aural and a visual appeal, with the lecturer selecting the aid most helpful to him and his students, promises to be more successful than simple oral communication" and "We have become increasingly convinced that these aids can help to improve the quality of teaching, and to ease and enrich learning processes."

Language Laboratories

Although the Committee's terms of reference referred specifically to the pure and applied sciences in institutions of higher education, the Report itself deals with the importance of modern media in the medical sciences and emphasises that many of its recommendations are applicable to teaching in the humanities and to learning processes in colleges, schools and in the Services. The Report evaluates the importance of Language Laboratories and there is an appendix on the design of the kind of accommodation required for the best and most efficient use of audio-visual media and aids.

Without attempting to trace fully the evolution of every modern aid, the Report contains many recommendations on the use of individual aids and on the kind of educational planning which is required if their potential is to be fully developed. It stresses that at local or institutional level, there is a widespread need to provide a co-ordinated communication service in most academic institutions, and at national level a Centre which would provide a focal point for the work of existing organisations

whose limited and often overlapping activities are unco-ordinated and sometimes unknown.

Such a Centre would concentrate on those services which cannot be rendered satisfactorily by smaller units, on the exploitation of new audiovisual media and aids, on the training of staff for university or college central units, on providing a co-ordinated cataloguing and library service and a comprehensive information and advisory service.

The Centre should also provide courses of instruction on new methods and should undertake investigations either independently or in association with an educational institution which has not the resources to solve a particular problem or advance a new idea.

Mr. Anthony Crosland, Secretary of State for Education and Science, following the report set up a National Council for Educational Technology. Some twelve months earlier he had spoken of the 'drawing revolution in the technology of education' and of the good effect this would have on the status of the teacher. Not all teachers, of course, are of this mind.

While many are enthusiastic, some are apathetic and a number are torn by doubts about the value and significance of modern media and aids. The Plowden Committee which inquired into primary education rebuts in its Report some of these doubts.

Enrich Enormously

"Some primary school teachers think that such aids to learning as broadcasting television, cine film, filmstrip and discs are the negation of modern primary methods"? the Report says adding. "This is a mistaken view.. They enrich enormously the resources available to teachers and children' and it goes on programmed

learning could relieve the teacher of some routine tasks and free them to exercise their influence more constructively."

It sums up by saying, "This is an age of increasing mechanisation. Inevitably, more and cheaper mechanical aids will find their way into primary schools. Teachers must, therefore, consider how they cause them best to enrich the ways in which children can learn'.

At every level of education new possibilities are being opened up by advances in the field of audio-visual media. It is no longer a question of using audio or visual aids as a way to help teachers to improve their traditional and established methods of teaching. New possibilities in both teaching and learning are now available to all who have the knowledge and the energy to develop them.

Against this background, and the probability that well before money was likely to be available to establish a National Centre other agencies would be carrying out some of the functions envisaged for it, the Secretary of State for Education and Science has come to the view that the right course is to set up a more modest body to be known as the National Council for Educational Technology. The Secretary of State for Scotland and the Ministers responsible for Defence, Labour and Technology are all associated with the proposal.

What will the Council do ? It will, in the words of Mr. Crosland, "give advice, collect and disseminate information, improve co-ordination, promote the training of staff, and encourage research and development—and it will advise, in the light of its own progress and of other developments, on whether a National Centre is still required" The Council will not merely encourage research and development projects by what it says as a body. It will

have access to funds which can be used to support projects recommended to it.

If, in the next few years, the potentialities

of modern audio-visual media are assessed intelligently and applied resourcefully, they can have a profound effect throughout the whole of our educational system.

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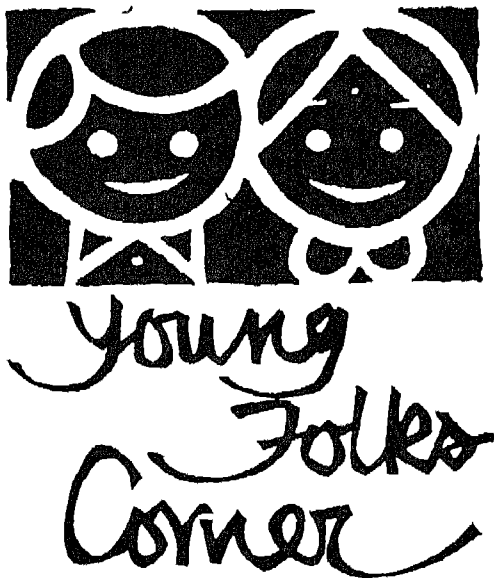
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THIS is no trite compliment, her distinc-
tion lies in the difficult subject of X-
ray crystallography, to which she has given
not only her skill and devotion—but per-
haps more outstandingly an intuitive
insight that calls for exceptional human
performance.

The Royal Swedish Academy said she
won the prize, worth just over £ 18,750
(tax free), for the determination of the
structures of important biological com-
pounds "by the difficult process of studying
their behaviour while they were exposed
to X-rays."



Mrs. Dorothy Crowfoot Hodgkin

The technique, the citation said, was
difficult to apply "and in complicated cases
it makes heavy demands on the investiga-
tor. In this connection Mrs. Crowfoot
Hodgkin has shown exceptional skill, in
which chemical knowledge, intuition, im-
agination and perseverance have been con-
spicuous. Applying this technique she
has succeeded in solving structural prob-
lems which it had not been possible to mas-
ter by other methods."

Professor Crowfoot Hodgkin is the
third woman to win the chemistry prize;
the others were Marie Curie (in 1911) and
her daughter, Irene Joliot-Curie (in 1935-
a shared prize). It is also the second Nobel
Prize in her family: her husband is a cousin
of Professor A.L. Hodgkin, who shared the
award for medicine last year.

First Crystallographer

She has the distinction of being the first-
X-ray crystallographer to determine the
chemical structure of any substance solely
by X-ray analysis, and is best known for her

work on penicillin and later on vitamin B-12, which is essential in combating pernicious anaemia.

In 1954, when Mrs. Hodgkin obtained her first results on vitamin B-12, chemical studies of the vitamin had led to the identification of several sidegroups, but had left the core of the molecule as the cobalt-containing complex of largely unknown constitution. Its structure and the arrangement of its side groups, became known only as a result of the -ray analysis by Mrs. Hodgkin and her colleagues.

This showed a metal-organic structure of a kind not hitherto encountered in nature, and of a complexity grater than any solved at that time by X-ray analysis. The structure has since been refined to a remarkable degree of precision.

In all her work Mrs. Hodgkin has shown notable inspiration. She has a genius for understanding what the initial illdefined electron density maps derived from X-ray analysis are trying to tell her. By interpreting correctly the first indistinct picture of the structure, and upholding her interpretation even if it conflicted with established chemical experience, she has been able to carry her analysis to their unexpected but right solutions.

Described as the world's outstanding exponent of the art of solving complex chemical molecules by traditional X-ray methods of trial-and-error and "refinement", she also shows an astonishing capacity for enjoying the responsibilities and pleasures of family life without appearing hard-pressed by the discipline of science.

News of the award—prof Hodgkin is the 22nd Briton to be awarded the prize since World War II—came to her in Ghana during a visit to her husband Mr Thomas Hodgkin, who is Director of the institute of African Studies at the University of

GHANA.

It has been said that Professor Crowfoot Hodgkin gives the misleading impression that she seems ready to leave her Oxford laboratory at the call of her family "just as much insurance" as Dr. Watson used to leave his practice to accompany Sherlock Holmes." But in fact she has an extraordinary capacity for concentration and is able to work through all sorts of distractions that would interfere with the mental processes of lesser individuals.

Her study of the arrangement of atoms in three dimensions from the directions in which the electrons that surround them scatter X-rays calls for a rather special kind of imagination and insight. This she has developed to a remarkable degree, and when asked once whether women might be better than men at imagining in three dimensions, she replied after a pause that she did not think that was it. Women, she suggested, were perhaps better at thinking of two things at once, because they spent so much of their lives doing it and perhaps that came into it.

Dorothy Crowfoot was born in Cairo in 1910, one of four daughters of highly intelligent and scholarly parents. Her father Dr. J.W. Crowfoot, was an historian and archaeologist, for some time Director of Education in the Sudan and later Director of the British Institute of Archaeology in Jerusalem. Much of her early childhood was spent in the Sudan and in Palestine, where she was introduced to archaeological excavation.

She went to the Sir John Leman School at Beccles, Suffolk and later studied chemistry at Oxford. After taking her degree there, Dorothy Hodgkin joined J.D. Bernal at the newly established Crystallographic Laboratory at Cambridge. This was housed in a dilapidated single-story build-

ing which formed part of Lord Rutherford's Physics Department, and was next door to the so-called "garage" where Cockcroft and Walton had just succeeded in the first artificial disintegration of the atom.

Together with Bernal she took the first X-ray photographs of protein, crystals which has been brought from Sweden, and made the startling discovery that proteins are highly organized molecules in which each of the many thousand atoms has its proper place. Back at Oxford in 1935 Dorothy Hodgkin infected her students with her own enthusiasm for X-ray crystallography, and many of them became her research students and collaborators later.

Two years later (1937) she married the historian Thomas Hodgkin; they have three children and three grand-children. Mrs. Crowfoot Hodgkin now has a modern laboratory at Oxford; but in the mid-1930s she had to work in a basement room in the University Museum, designed by the Victorian art critic Ruskin to provide a home

for all the Natural Sciences. It is said, visitors approached the Crystallographic Laboratory through a vast, lofty hall rather like a Victorian railway station, but filled in place of trains by the skeletons of dinosaurs and other prehistoric animals.

To mount the crystals for her X-ray analysis she had to climb a ladder to a gallery by the windows where her microscopes were placed—a perilous journey when carrying, as in the early days of penicillin and vitamin B-12 work, perhaps the only available good crystal of the substance under study. Mrs. Hodgkin never seemed frustrated: she had a facility of absorption which made her oblivious of surroundings.

She was elected a Fellow of the Royal Society in 1947, in recognition of her work on cholesterol and penicillin one of the first women to be so honoured.

It is understood that Professor Crowfoot Hodgkin would like to set up a scholarship scheme at Oxford and contribute something to the cause of peace and famine: this was her reported comment when told about the Nobel Award.

tics, topology, set-theoretic approach to probability, computer and linear programming. The basic philosophy behind the choice of these courses was to acquaint the participants with some of the key ideas of modern mathematics together with some of their applications. The participants were provided with the following books (i) S.M.P. Book I&T4 (together with teachers' guides) (ii) S.M.P. Advanced Part I (iii) Transformation Geometry by Jeger (iv) Some lessons on Modern Mathematics by A.T.N. (v) M.M.P. Vol I. The subject matter in the S.M.P. (or M.M.P.) books formed the basis of discussion by the participants in larger groups. Each participant was assigned a topic from one of the SMP or MMF topics beforehand and he or she had to initiate the discussion on that topic on the day fixed and announced before. Sometimes, such discussions were extremely useful and lively, particularly if it centred round a topic which had a relevance to what is being taught at schools at present. There was another part of these discussion programmes; namely, the reporting of some good articles on some aspects of mathematics teaching from the bulletin Mathematics Teaching Published by A.T.M. (U.K.) Sometimes small discussion groups were organized with a participant as a leader of group. It was left entirely to the discretion to the leader to choose the topic. The topics were usually either, from the text materials given to them or, these with which they were concerned at the schools. There was another kind of activity by the participants, namely, the presentation of a model lesson on any topic of new mathematics, for these were considered to be highly useful so far as actual teaching was concerned. This is a new feature of the Institute in this year. Another new item introduced in the pro-

gramme was the demonstration class. Two such classes with two different groups of boys from two Calcutta Schools, were taken by the two British Consultants and these were exceedingly successful and valuable too, for these helped a good deal to remove the scepticism that often hovered round the minds of some of the participants' at the school level. In all the weeks, two periods were allotted for film-shows and the films such as 'I do and I understand', 'Maths Alive', 'Maths & Monster' etc. that were essentially mathematical enabled the participants to get a glimpse of what others have been doing in regard to new mathematics. Some interesting film strips (some on slide-rules and on transformation geometry) were brought by Mr. Taylor from U.K. and these were shown to the participants. There was a library attached to the Institute and participants availed themselves of some of the supplementary books kept there, in the afternoon. A quiz-contest was organized and this was very exciting. Tutorials would normally deal with the topics taken up in the lectures.

There were three guest speakers at the Institute. One of them Mr. B. Dutt belonging to industry, delivered two lectures on computers and linear systems, Dr. M.C. Pant, Head of the Department of Science Education, NCERT talked to the participants on some aspects of science education in India. Dr. J. Schroggs, Chairman of the Department of Maths, Arkansas University (U.S.A.) gave a useful lecture on mathematics programmes in Schools in U.S.A.

The participants visited the computer centre of the University and also the Birla Science Museum of Calcutta. A book exhibition was organized by the British

Council at the University for a week and the participants could get an opportunity of going through some important publications in science and mathematics in U.K. A bulletin containing articles on efforts for reforms in mathematics education in our country and abroad by distinguished persons was published and distributed to each of the participants. The participants also attended three meetings of the Mathematical Association of Jadavpur, in which the three foreign guests talked about some interesting topics in mathematics.

The Summer Institute was an opportunity to the NCERT Study Group in Mathematics at the University to look for the reactions of the materials prepared by it from the participants of the Institute. As in last year, some cyclostyled materials such as School Geometry—A new book, 'Transformation Geometry Pt I', were distributed to the participants who in turn, were requested to give to the Director of the group their views. Apart from these each participant was also given a cyclostyled copy of the Geometry curriculum for middle schools together a report of the activities of the group. Some of the periods of the last week were entirely set apart for these discussions and all the members of the Group, including the four school teachers, were present in each of these discussions. The interest evinced by the participants in these materials would be highly useful in recasting the materials.

A Note on Courses in New Mathematics

The main purpose of the courses is to touch briefly upon a number of key ideas that constitute what has come to be known as 'new mathematics'. It is a necessity that a teacher should be well aware of what

exists beyond what he just teaches. Further if in keeping with the avowed goals for curriculum in new mathematics, a teacher is to introduce effectively modern concepts in an intuitive and informal manner to his students, he has to know the form of treatment of the topics. The courses taught at this institute have been framed largely with this end in view. The guiding principles in formulating the courses are: (i) they should reflect the contemporary view of what mathematics is and what it does; (ii) they should reckon with the abstract nature of mathematics; (iii) they should take into consideration the aspect of application of mathematics. It may, thus, be held that these background courses containing some unifying elements will enable the participants to get the glimpses of mathematics as an integrated whole and not as mutually exclusive branches (Algebra, Geometry and Arithmetic) as has been followed hitherto.

A course in mathematics has to proceed with 'set theory' as a basis, for it is largely through the set theory, mathematics has acquired a unity.

A preliminary discussion on sets will lead into discussion on punched cards and 'transformations' (initially only the *isometries*), that will lead to discussion on 'matrices' and 'vectors' and finally, to 'groups'. Then the geometrical aspect of 'transformations' will be taught by one of the consultants from U.K. and the other consultant will tackle them from the algebraical point of view and in this way, they will knit together their work nicely.

The naive understanding of set theory, so basic to the comprehension of to-day's mathematics, will be made use of by another member of the staff to proceed with

the 'operations' and algebra of 'sets relations and functions.'

It is an admitted fact that the algebraic structures such as *group*, *ring*, *field* and *'integral domain'* from the foundation to the study of all mathematics, as they, too, are the unifying elements. A formal study of these structures with a bit of details will be taken up by a second member of the staff. He will devote a part of his lectures to another important idea on *'vector spaces'*

An inkling of the elements of *'theory of numbers'* such as *'whole numbers, prime and composite numbers, primes factorization, divisibility, L.C.M., G.C.M. etc.* will be given by a third member of the staff. A part of his lectures, will be set apart for descriptive statistics dealing with *'histograms, frequencies, median, mode, arithmetic mean, quantities, decibles, standard deviation etc.'*

Undoubtedly, *'topology'* is one of the core topics of mathematics and some lectures, essentially based on appeals to

institution, will be delivered on it. The same gentleman will deal with two kinds of applications of set theory. The first of these is *'probability'* that synthesizes much of all fundamental elements and structures referred to above. The second of them is *'mathematical logic'* that would be introduced as an application of operation on a set and a bit of *'Boolean Algebra'* may be dealt with.

The last two topics on *'linear programming and computers'*—are designed to give an idea how the basic skills acquired in mathematics are relevant to the solution of applied problems in industry. A member of the staff will dwell upon each of these topics.

The above represents, in brief, the tentative outlines of the course to be taught of the Institute. But it is the teaching, it is the method and it is the approach that can unfold the essence of the syllabus that might have to be adapted to meet the classroom situations.

Science Notes

First Signs of Life and the Rh Factor

IN some cases of Rh incompatibility, where the mother is Rh negative and the father Rh positive, the gynaecologists want to know whether the child in the womb is affected. In Hadassah, Prof. W.Z. Polishuk has introduced a new method known as amniocentesis, which involves the removal of a small quantity of amniotic fluid from the womb. The doctors examine the fluid in a special spectrophotometric examination. This tells them to what extent the child is affected and whether they have to deliver it immediately by Caesarian operation or whether they can wait for a normal delivery.

Another method being used is placentography, whereby the doctors determine whether the placenta is functioning normally or not. In this method isotopes are used to locate and to detect any malfunction of the placenta. In this way, the gynaecologist can determine whether there is any danger to the child in the womb, as, for instance, in the third stage of pregnancy in cases of bleeding, or whether drugs should be administered to benefit the foetus. Another technique being used at Hadassah to establish the condition of the foetus is the study of certain enzymes in the leucocytes or white blood cells. If the enzymes change in quantity then the doctors know that the patient must be treated or the prognosis should be evaluated. Or the cytology of the cells of the vagina may be studied to evaluate placental function during the last trimester of pregnancy.

Saving the Baby

The number of people whose red blood cells are Rh negative varies in different countries. In China and Japan, for instance, the percentage is as low as one per cent; among the Basques, in Spain, it is as high as 35. Since Israel is a land of immigration, the percentage varies according to the country of origin of the various communities: Yementies, Persians and Kurds have a two per cent Rh negative frequency, while the percentage among the communities of European origin reaches 15.

The Rh negative factor in a person's blood only becomes important when husband and wife show what is known as Rh incompatibility. In cases where the mother is Rh negative while the father is Rh positive, and, in addition, both his genes are Rh positive and the Rh positive factor is passed on to his offspring in every case,

a situation arises in which the mother is Rh negative and the foetus in her womb is Rh positive. The mother then produces antibodies against the red blood cells of the foetus, and these cause it to suffer from haemolytic anaemia and jaundice. This invariably results in the death of the foetus if it is left in the uterus. In fact, the baby is doomed, unless it is removed from the womb and receives appropriate treatment by exchange transfusion. This is naturally not feasible in the fifth, sixth or seventh month of pregnancy, when the child is not yet viable.

Until four years ago, there was no solution to the problem, and all such babies were born stillborn. Then a New Zealand doctor by the name of Lily performed the difficult task of giving blood transfusion of fresh Rh negative blood to the foetus while still in the mother's womb, so that it could continue to grow there until viable. In this way, the results of the blood disease were checked for a while and the life of the foetus prolonged. Giving these intra-uterine blood transfusions is an extremely difficult technique, requiring great skill, modern X-ray television equipment and teams of well-trained doctors.

The transfusion is given by means of a needle into the body cavity of the foetus and there is great danger that the needle may damage the foetus in some way. In order to avoid this, a contrast medium injection is given into the mother's womb before the transfusion is given to the foetus. The foetus swallows the contrast medium and this causes its intestine to show up clearly on the X-ray television screen.

To perform the transfusion X-ray television is used. This has the advantage that radiation is reduced to a minimum and the image is thrown on to a screen some distance from the operation, so that members

of the team can all see the operation in process. The doctors watch the foetus on the X-ray television screen and because the foetal intestine shows up clearly, the needle may be guided so that it does not damage any other organs of the foetus. When the needle penetrates the abdominal cavity of the foetus, a polyethylene tube is passed through it, and a blood transfusion of fresh Rh negative blood belonging to the O group is given slowly over 35 to 40 minutes. The polyethylene tube and needle are then removed.

Although there is danger to the foetus in the use of this technique, it must be remembered that without it the baby is doomed to die. A decision as to just when to start giving the foetus these intrauterine transfusions is made by the doctor according to a pigment test of the fluid in the uterus which surrounds the foetus, known as amniotic fluid. This fluid is coloured yellow brown by the destruction of red cells in the foetus. According to the colour of the amniotic fluid the doctor knows the state of the haemolytic disease in the foetus. If the foetus is six or seven months old when the decision is taken that it needs these intrauterine transfusions, then these will have to be given every two weeks until the foetus is big enough to be delivered either by Caesarian operation or by induced labour.

A team of doctors in the Gynaecology Department of the Jerusalem Hadassah-Hebrew University Medical Centre has recently performed this difficult technique of giving blood transfusions to foetus while still in the uterus, for the first time in Israel.

Dr. Zukerman reports that the mother, who is of Iraqi origin, has been in Israel for 17 years. Her husband is also from Iraq. The mother has three previous stillbirths in Israel.

She came to Hadassah Hospital when the foetus in her fourth pregnancy was six months old. According to the pigment test of the amniotic fluid, the foetus would die if a blood transfusion were not given to it within six or seven days.

The baby at that age is too small to survive a Caesarean operation. The baby girl was born last week, after having three blood transfusions while it was still in the womb; it was given three complete blood exchange transfusions within the 36 hours after birth. The baby is ten days old and is taking its milk from a bottle already. The mother is extremely happy for she knows that but for this new technique she was doomed to be childless.

The intrauterine blood transfusion technique is being used today in America and England. However, it is regarded still as extremely difficult. Every case in the world is reported and published in literature and in only 50 per cent of cases does the foetus survive.

In the last few weeks, five pregnant women with the Rh incompatibility factor have come to Hadassah for treatment by means of the new technique. They know that they have no hope of delivering babies who are alive and well without the intrauterine blood transfusion technique.

By COURTESY, Consulate of Israel, Bombay.

Tethered Mosquitoes used in fight against Elephantiasis

TETHERED mosquitoes, flying in a stream of air but not moving, are being used in the fight against the tropical disease elephantiasis.

At the University of Liverpool, the insects are under study because the worm that causes the disease is carried by mosquitoes. Changes of wing-beat frequency are being examined, because during a part of its life-cycle the worm lives in the flight muscle of the insect, so changes in infected mosquitoes' flight performance may require changes in control measures against the carriers.

Cause of Disease

Elephantiasis is caused by blockage of the lymphatic glands and channels by parasitic worms, called filariae. Legs and arms can become swollen to monstrous proportions. The worms are transmitted by mosquito bites. They mature in the human body and then release millions of microfilariae into the blood stream, from where they are taken up again by mosquitoes feeding on blood for the round to begin again.

Flight muscle is the power plant of the mosquito's wings and it is richly supplied with oxygen and nutrients. The parasitic larvae feed on this and, of course, affect the mosquito's flying capabilities. The aim of the Liverpool research is to find out how much the effect is, by measuring the wing-beat frequency and other things such as duration, speed and range of flight.

Wind Tunnel

The mosquito is tethered by a dab of glue into an entomological pin, being fixed in the correct flight attitude. Placed in a small wind tunnel, it will fly if a gentle air flow is directed on to it. Wing-beat frequency is measured in two ways—by a piezoelectric pick-up attached to the pin and by a stroboscope. Mosquitoes have also been flown on a round about to measure speed and distance at the same time as

wing beat frequency, so that this could be related to speed changes. Frequencies vary, but mostly they are in the range of 24,000 to 30,000 beats a minute.

Such research should assist in the cam-

paign against elephantiasis, but it may help against other mosquito-borne diseases. These include malaria, yellow fever and dengue fever, which affect millions of people in different parts of the world.

By courtesy : British Information Service

ELEMENTS OF MECHANICAL ENGINEERING

A Textbook for Technical Schools

by

S. K. Basu

Crown quarto, pp ix+82, 1967

Rs. 3.20

Introductory book for students of secondary schools, specialized technical schools and those at the earlier stages of the polytechnic course. Designed to develop in the young reader an understanding of the basic principles of mechanical engineering the book discusses the application of these principles in relation to actual human needs.

Available from

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National Council of Educational Research and Training
71/1 Najafgarh Road, New Delhi 15**

News and Notes

Secondary School Science Teaching Project

DETAILS of concept analysis of the syllabi in Physics, Chemistry, Mathematics and Biology of the senior high school were made in the Department. Writing assignments for chapters of the different books were made and the work has commenced on this stage of preparation of instructional materials.

The periodical school visits have been resumed and three batches of experts and officers of this Department have started visiting experimental schools in Delhi.

The English edition of Part III of the series 'Science for Middle Schools' have come out in English. The Hindi versions are expected. Those that have come out are Part III of Physics and Biology and Part II of Chemistry and Part III of Arithmetic—Algebra and Geometry Part III

Arithmetic—Algebra in Hindi has also been published.

Unesco—Unicef Project

Under this project dialogue between the Central Ministry Team and the State Directors of Education has begun. Dr. M.C. Pant and Mr. A.W. Torrie, UNESCO/UNICEF Consultant went to the States of Tamil Nadu, Gujarat and Maharashtra. During the quarter they held discussions with the respective Departments of Education and Secretaries of Education on the matter of implementing the project in the State. The Tamil Nadu State has drawn up a programme of the project in experimental schools all over the State. As the first part of this agreement materials are being sent from the Department for purpose of translation and adaptation.

Shri N.K. Sanyal and Mr. A.W. Torrie went to the states of West Bengal, Orissa and Assam in September 1969 as members of the Central Ministry Team to discuss with the State Governments the implementation of the pilot project of the organization of science education in the school level. They had discussions with the Education Secretary, West Bengal together with the D.P.I. and senior officers at Calcutta; with the Minister of Education, D.P.I. and officers of the Education Department at Bhubaneshwar and the Minister of Education, Secretary, DPI and officers of the Education Department at Shillong. The target dates for the translation, printing and training programmes were decided. The Unicef and the NCERT were to supply equipment and instructional materials to the States.

The manuscript for Class III textbook has been completed and it is being mimeographed and copies would be sent to the

States and other places to be used for their translation and for feedback of opinion. Later this would be printed to be used in the experimental schools.

Study Groups

The Coordinating Committee meeting of the study Groups was held on 12th September 1969 under the Chairmanship of Dr. D.S. Kothari. The Committee has recommended that Study Groups should be continued beyond 1970 as the scope of work of Study Groups has now been widened. The groups are now preparing not only the text and teachers guide but are also developing proto-types demonstration kit, film-strips and supplementary reading materials. It has been recommended that the Study Groups may be continued up to March 1971 at the first instance.

The materials already prepared by this Study Groups would be made available to all the States for try out in 30 experimental schools in each State. The States would be using this material either by adopting or adapting it.

Mathematics Study Group

The trial editions of Class V and VI Algebra and of Class V, VI and VII in Geometry have been prepared. These are to be reviewed by the Editorial Board in October, 1969.

Physics Study Group

These groups have prepared Parts I and II and the former is in the press. The Teachers' Guide in Physics is under preparation.

Chemistry Study Group

The Groups have prepared Book I, II and III and work on books for Classes

IX and X has begun. The Chemistry Groups have also started developing materials for film-strips.

Biology Study Groups

Text material for Classes VIII, IX and X are nearing completion and it is hoped that these manuscripts would be sent to the press by December, 1969.

Mathematics Study Group

Dr J.N. Kapur, Convener of Study Groups in Mathematics has gone to the United States of America on assignment for one year. Professor K. Venkatachaliengar, the Director of the Study Group at Bangalore has been requested by the Co-ordinating Committee to act as Convener for the Mathematics Study Group during the absence of Professor J.N. Kapur.

National Science Talent Search Scheme

Preparations are being made for the holding of the N.S.T.S. Aptitude test in January 1970. Application forms have been distributed to various institutions all over the country.

Details of the programme in connection with the conduct of examination in regional languages have been finalized with the Directors of the N.S.T.S. Associated Centres at different Universities. A team of Science Talent students from U.S.A. and U.K. came to India at the invitation of the NCERT and the Ministry of Education. The team consisted of 10 American students and 5 British students of age between 17 and 18. The group from each country was led by an eminent Professor of that country. The team with their leaders were received at the Auditorium of the Department of Teaching Aids on September 11, 1969. Students from abroad

were given a chance to mix with the Science Talent students of India. They lived together for three days and a visit to Agra for the visiting team was arranged on 10th September. Prof. Herry Messel of the University of Sydney School of Physics was also here at the same time. As a sponsor of this International Science School he was happy to be associated with the NCERT.

"The Statistical Report for the year 1967" and "Project Reports by Young Scientists" for the year 1967-66 were brought out.

Supplementary Readers

"The Discovery of Oceans" had been printed. This publication brings the total number to four so far. There are 3 manuscripts still in the press.

Unesco Experts

Dr. Y.I. Naumov, the expert in Chemistry in the team of Unesco Experts left New Delhi in July '69 after the expiry of his term in the team. Dr. M.F. Kolpakov, expert in Physics joined the team in September 1969.

Fellowship Training Programme Under The Ncert-Unesco Project

Under this programme five persons from the Department have gone to USSR for training and observation of their school education system in science in the USSR. The officers who have gone are—Dr. M.C. Pant, Head of the Department for two months, Shri R.C. Sharma, and Dr. B.D. Atreya. Readers in Mathematics, and Chemistry, Shri S.P. Sharma, Lecturer in Biology, Shri Mohinder Singh, fine mechanic of the Central Science Workshop, each for six months, Mr. Krishna Murti of the

Central Science Workshop is already in the USSR. He went in the month of July.

National Council of Science Education Participants Programme. Mr. Rajendra Prasad from the Department has proceeded to the U.S.A. for a period of three months under this programme.

Central Science Workshop

New sections of the workshop like the Optics Sections, Electrical/Electronic Section, Plastic Section, Packing and Assembling Section have been commissioned for work. Machines which had been received earlier but not used for lack of power have been erected in these sections.

A training course to train our workers on the new machines was started and imparted to a few workers of this workshop outside their office working hours. The training course is for five weeks after which there will be a trade test. The successful candidates will be awarded certificates.

The Central Science Workshop has now been divided into two separate wings one for production and the other for development. The production work includes planning and control, production and maintenance. The development department consists of proto-type development, design and estimation, inspection, quality control and standardisation.

Development

The development of Class VII kits was conducted and completed during this period. The kits have been tried by specialists in the Science Department and after their approval plans have been drawn for the production of 300 kits.

Development of class VI, VII and VIII

items in Mathematics were done during the quarter.

Work of the development of Class VIII item in Physics was started from 1st August 1969. The ray box which would enable all experiments in optics to be performed has since been developed. Electrical items have also been developed and drawings are being made.

Production

Work on 'Project 250' for Class VI has been completed. 'Project 300' for Class VII has been started from 1st September, 1969.

Contributions by the Department to other Agencies

The officers of this Department have served as experts on the Interview Board of Nigerian High Commission for selection of Science teachers from India to serve in Nigeria. Several such meetings have taken place.

Visitors

During the three months of this report

the Department received a large number of distinguished visitors from the different parts of the world. All these visitors spent considerable time in the Department examining the various materials developed for teaching of Science and Mathematics and visiting the Central Science Workshop and Instructional Material Centre of the Department. Some of the distinguished visitors were presented with the selected publications of the Department. The following are some of the important visitors.

1. Shri Wainasuriya, Director of Education, Ceylon on 14th August, 1969.
2. Dr. Norman Alison of the Nuffield Project and Dr. F.W. Franklin of WCOTP on 27th August, 1969.
3. Mr. Zarubin of UNESCO on 27th August, 1969.
4. Dr. Rozar Kampa of University of East Anglia, Norwich U.K. visited on 12th Sept. 1969.
5. Vocation Guidance Trainees visited the Department on 13th August, 1969.

SCHOOL SCIENCE

Vol. 7

December 19

In This Issue

CONSERVATION EDUCATION IN NEW SCHOOL
SYLLABUS IN INDIA

*

CHEMISTRY AND CONSERVATION OF NATURE

*

CONSERVATION AND ENVIRONMENTAL
EDUCATION

*

SCIENCE NOBEL LAUREATES OF 1969

*

THE MAN THE EARTH AND THE
HEAVENLY BODIES

*

NEW DIMENSIONS IN SCIENCE EDUCATION

*

STUDY OF SURFACES—PART III (INTERFACE)

*Some item from the Physics-kit developed
for Middle Schools. This set up helps to
impart simple mental model of the particle
structure of substances*



NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

CONTENTS

	International Union for Conservation of Nature and Natural Resources		253
	Conservation Education in the New School Syllabus in India	<i>S Doraiswami V.M Galushin</i>	256
	Environmental Education Its Relevance to the Problems of Rural Areas in North-West Europe	<i>Tom Pritchard</i>	262
	Chemistry and Conservation of Nature	<i>S.A. Balezin</i>	270
	Notes on Conservation and Environmental Education	<i>Jonathan Holliman</i>	274
	Science Nobel Laureates of 1969	<i>R.K. Datta</i>	277
	The Man, the Earth and the Heavenly Bodies	<i>K.C Adlakha</i>	280
	New Dimensions in Science Education	<i>J.K Sood</i>	285
Chief Editor M.C. PANT	Study of Surfaces—Part III (Interface)	<i>L.D Ahuja</i>	290
	Plant Life of Rajghat	<i>G S Pathwal Miss Lalita Kakkar</i>	295
Associate Editor S. DORAISWAMI	Classroom Experiments		
	Plant Physiology Kit	<i>A C Sahgal</i>	293
	Introducing Structure of Substance in the First-Stage Course of Physics in the Schools	<i>K J Khurana A A Tamarn</i>	312
	Science Abroad		
	Nitrogen Fixation	<i>John Postgate</i>	417
	Computer Simulation and Biological Systems	<i>Loid Kelym B J Hammond</i>	322
	Science Notes		327
	News and Notes		334

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TO OUR CONTRIBUTORS

School Science is a quarterly journal intended to serve teachers and students in schools with the most recent developments in science and science methodology. It aims to serve as a forum for exchange of experience in science education and science projects

Articles covering these aims and objectives are invited.

Manuscripts, including legends for illustrations, charts, graphs, etc., should be neatly typed, double spaced on uniformly sized paper, and sent to the Editor, School Science, Department of Science Education, NIE Buildings, Sri Aurobindo Marg, New Delhi 16. Each article may not normally exceed 10 typed pages.

The articles sent for publication should be exclusive for this journal. Digests of previously published articles modified to suit the scope and purpose of **School Science** will be accepted. In these cases the name of the journal in which the original article appeared must be stated.

Headings should not be underlined.

Selected references to literature arranged alphabetically according to the author's name may be given at the end of the article, wherever possible. Each reference should contain the name of the author (with initials), the title of the publication, the name of the publisher, the place of publication; the volume and page numbers.

In the text, the reference should be indicated by the author's name followed by the year of publication enclosed in brackets, *e.g.*, (Passow, 1962). When the author's name occurs in the text, the year of publication alone need be given in brackets, *e.g.*, Passow (1962)

Illustrations may be limited to the minimum considered necessary, and should be made with pen and indelible Indian ink. Photographs should be on glossy paper, at least of post-card size, and should be sent properly packed so as to avoid damage in transit

International Union for Conservation of Nature and Natural Resources

THE International Union for Conservation of Nature and Natural Resources (IUCN) was founded in 1948 and has its headquarters in Morges, Switzerland. It is an independent international organization, whose membership comprises states, governmental and private organizations, and international groups. It represents those who are concerned at man's modification of natural environment through the rapidity of urban and industrial development and the excessive exploitation of the earth's natural resources, upon which rests the foundations of his survival

Objectives of IUCN

The main purpose of IUCN is to promote or support action which will ensure the perpetuation of wild nature and natural resources on a global basis, not only for their intrinsic cultural or scientific values but also for the long term economic and social welfare of mankind. To further these objectives, the union promotes:

Awareness through education, so that as many people as possible may understand

the value and importance of renewable natural resources and appreciate the need to use them wisely. Activities include, general assemblies, regional meetings, symposia, and the dissemination of information through the press, radio, films and T.V. and through publications.

Research to discover the best measures for conservation and to advance the study of ecology upon which all practical conservation depends

Assistance in providing advice based on ecological considerations, scientific and technical data, source material and references, and all contacts required for the coordination and conduct of practical conservation programmes.

Action on a national and international scale, by enlisting the cooperation of governments and international agencies in support of conservation programmes as well as in strengthening legislation and improving its enforcement

What IUCN Does:

The Union's main field of activity lies in conserving the plants and animals, the soil, water, air, and other natural wealth which constitute the earth's basic assets; dealing with threats to the quality of the natural environment especially of wild lands and living resources, and proposing methods by which such problems may best be resolved and promoting action and educational measures to advance the quality of the human environment.

The Union takes a leading part in the protection of rare species, particularly those threatened with extinction, in the perpetuation of natural habitats for wild animals, and in encouraging the establishment of national parks, reserve and sanctuaries for aesthetic, scientific and recreational

purposes. The Union is concerned at the encroachment of man upon the natural scene, and regards as of particular importance the need for ecological principles to be applied to all land-used planning. Since its foundation, the Union has dealt directly with governments on great many occasions, in order to draw attention to the dangers threatening the natural resources of their countries. These intercessions have invariably been received with understanding and usually followed by constructive action.

Organization of IUCN

The IUCN operates through a number of commissions and committees, each of which specialises in different aspects of the Union's work. Chairman of commissions are appointed by the General Assembly; members are appointed by the Executive Board on the recommendations of the commissions. The commissions are responsible to the Executive Board, a body comprising upto 18 leading conservationists, representing the principal regions of the world. The headquarters and secretariat of the Union and the important van Tienhaven library are at Morges, Switzerland.

IUCN Commissions

Survival Service Commission: Its task is to prevent the extermination of threatened species of wild life. It investigates the status and ecology of rare species of plants and animals and gives advice and help in safeguarding them and the habitat upon which they depend. The commission maintains a list of threatened species and institutes appropriate action to safeguard them.

2. *Commission on Education.* Primarily responsible for educational aspects of the Union's work and acts as a clearing house for educational material relating to the conservation of nature and natural resources,

the commission uses the press radio films and T.V. for advancement of conservation education. Regional committees have been set up to ensure that its activities take effective account of local conditions and needs.

3. *Commission on Ecology:* Serves as the primary scientific body for the Union. It gives advice on proposed projects, sponsors scientific meetings, assists with the technical aspects of general assembly programmes and maintains liaison with the International Biological Programme. It has sub-committees to specialise on (1) Ecological aspects of soil and water conservation, (2) Ecological effects of chemical control (Pesticides) and the Ecological problems of introductions (plant and animal).

4. *International Commission on Natural Parks:* Specialises in encouraging the establishment of National Parks.

5. *Commission on Legislation:* Provides information on legislation or regulations concerning conservation of nature and natural resources to governments, parliaments, and their members and national and international organizations. It also advises governments parliaments, and other authorities on proposed legislation or regulation.

Commission on Landscape Planning

Concerned with the relations of man and his environment. Since man's present well being, and indeed his future survival, depends upon how well he uses and manages the earth's natural resources, planning for land use assumes a position of urgent and vital importance.

IUCN Meetings

The Union convenes a General Assembly every third year in order to act upon issues of current importance and to serve as a forum for discussion of conservation

problems. Previously the meetings have been held in Fontainebleau (France), Brussels (Belgium), Caracas (Venezuela), Copenhagen (Denmark), Edinburgh, (Scotland), Athens (Greece), Warsaw (Poland), Nairobi (Kenya), and Lucerne (Switzerland). The Tenth General Assembly was held in New Delhi from Nov. 29—Dec. 1 1969. It was inaugurated by the Prime Minister Srimati Indira Gandhi. Regional meeting to focus international attention on conservation problems shared by more than one nation are convened periodically.

Publications: Proceedings of general

assemblies and reports of conferences and technical meetings are published. A number of special publications are also issued. It publishes a quarterly Bulletin on current conservation topics of international interest. An Annual Report is also published.

There are 36 governments who are members of IUCN India joined this band and became a government member. Besides these, there are 200 organizations from all over the countries who are members.

S DORAISWAMI

SUPPLEMENTARY READERS IN SCIENCE SERIES

The general aim of this series is to stimulate the interest of school children in the world of science and to keep them in touch with the more significant developments that are taking place in its various fields.

WEAPONS: OLD AND NEW

by

Mir Najabat Ali

Foolscap quarto, pp 76, 1967

Rs. 2.25

This fascinating little publication is a primer on weapons, both old and new. The book is attractively illustrated and describes interesting weapons such as the boomerang, the harpoon and even the South American bola. It talks of swords of many kinds, of guns and tanks and missiles, and takes the story right up to latest inventions of modern warfare.

Enquiries:

Business Manager, Publication Unit,
National Council of Educational Research and Training,
N.I.E. Campus, Sri Aurobindo Marg, New Delhi 16

Conservation Education in the New School Syllabus in India

S. Doraiswami

*Department of Science Education, NCERT,
New Delhi*

V.M. Galushin

Unesco Expert, NCERT, New Delhi

THE problem of introducing the concept of Nature conservation in the school curriculum, covering the entire field of biology can be considered by no means simple. The problem acquires deeper significance, when it is to be dispensed to children of the primary middle and high schools (secondary schools).

The bulk of the population in India is in the villages and their main occupation is agriculture. The raising of the crops is still done according to age-old traditional manner. But with the extension of the impact of agricultural research, the farmers are slowly getting enlightened and they are adopting modern methods of cultivation. Still in

many respects the practices are tradition-bound. Many of the rural folk are not even aware of the impact of human society on the balance in Nature. One cannot explain the thoughtless destruction of plants and animals, the removal of green cover from areas, the cutting away of barks from avenue trees and the burning of cowdung as fuel, which could otherwise be used as manure to enrich the soil. The rapid and allied developments that have taken place in India since the days of independence and the rapid rate of urbanization of rural areas have all led to the decrease in the number of many flourishing species of flora and fauna. Many projects undertaken by man have pushed away further the natural jungle barriers. The uncertain monsoons and the need to divert all available resources of water to food production has made inroads into what was once a luxurious natural biome in many parts of India. In such a context, it is not surprising that many of the Indian children are not even aware today of the vast potential both of animals and plants in our country. The gradual disappearance of animals which were once well known in this country, like the cheetah, the black buck, the rhinoceros, the tiger and even the lion is an eye-opener. Intensive measures undertaken by various agencies to promote an increase in the vegetative cover of the land and conservation of wild life have had very little impact on the minds of the younger children, except as slogan catching weeks celebrated once every year.

Man is specially responsible to develop methods and techniques to use the resources of nature. Conservation education to be effective must be given to members of the population and it is best begun when they are young, and in schools. This paper describes how this problem has been tackled

Paper read before the 10th General Assembly of the International Union of Conservation of Nature and Natural Resources, held in New Delhi on Nov 28, 1969.

by the Department of Science Education in the National Council of Educational Research and Training, which has been entrusted with the task of preparation and implementation of new syllabuses and other materials. This has been achieved to some extent by laying enough emphasis on conservation education in the science syllabuses, particularly in biology. Two sets of curricular materials have been prepared, one by the biology group in the Department of Science Education from class I to class XI and the other by the Biology Study Groups set up by the NCERT consisting of professors and others at university centres. In the following pages an attempt will be made to show how this problem has been tackled by these groups.

Conservation Education in School Syllabus

In the majority of States in India, the existing General Science syllabuses for the middle schools and the biology syllabuses for higher secondary schools contain some elements and topics regarding conservation of plants, animals and soil; and the prevention of air and water pollution.

Conservation Education in New School Syllabus prepared by the Department of Science Education

It was felt that a better impact of the need to conserve natural resources could be emphasized on the minds of the school children by placing a greater emphasis on the abounding natural resources available in the country and how these resources are gradually diminishing due to intervention by man. In following these topics the child learns to love and respect the things that surround him.

The syllabus for the school has been prepared for three levels; for primary, schools (classes 1-5, 5+ to 10+ age group)

the middle schools (classes 6-8, 10+-13+) and the high (secondary) schools (classes 9-11, 13+-16+). Topics concerning conservation of plants, animals, soil, air and water are included as also a special section completely devoted to conservation of nature. An environmental approach runs through the entire biology course for the middle school and special chapters on ecology for the high school. These give the students a basic knowledge of the close interrelationships and interdependence in nature.

Primary School

The biology sections of the general science course for primary school contain elements of conservation of water, atmospheric air and soil, and some facts about plants and animals in the environment. When dealing with "Rocks, soils and minerals", concepts about erosion and man's attempts to control their action are included. The pupils are made aware of the diversity of plants and animals and their adaptations to environment and to each other. The importance of plants and animals is also stressed.

Middle School

The textbooks, teachers' guides and other materials prepared for the three years deal mainly with a systematic study of plants, animals and man. These books contain some concepts and topics regarding conservation. Each chapter of the biology syllabus for classes 6 and 7 gives some materials about conservation of plants and animals. For instance, in the botany course (class 6), the chapters "Plants and their environment" provide pupils definite ideas of the rational and careful use of plants. In the Zoology course (class 7) the chapter on 'Arthropoda', 'Fishes', 'Birds', and 'Mammals' include special topics concerning natural and economic significance of these groups and

the care of useful species. In the last chapter in Zoology course a special stress is laid on the interrelationship of the living and non-living things in nature and on the dynamic equilibrium in nature. On this base, pupils would understand the necessity for conservation of nature as a careful treatment of natural resources. The material for this is mostly provided in the teachers' guide, particularly in the concluding chapter of the zoology course.

In class 8, the biology course concludes with an important section on "Man and his Environment". This is a summary of the entire biology course from the ecological angle, and also serves to bridge the middle school biology with the high school biology. The last part of this section is "Man and conservation of Nature."

Thus, a conservation education runs through the entire syllabus and also forms a part of the final section of the biology course of the middle school. A pupil, at the end of the 8th class—many of whom go to agriculture, industry, forestry, commerce etc., gets the main ideas about the careful treatment of nature. He can, and we hope he will use this knowledge in his everyday work and life.

High Schools (Secondary School)

The course of biology at the high school includes topics on different levels of biological organisations like:

1. Molecules and cells
2. Organisms
3. Populations and natural communities.

Part V of this course is entirely devoted to Ecology (85 periods). The chapter on "Natural Communities" (56 periods) in the first year of high school consists of four sections, (1) Populations (12 periods); (2) Ecosystems (16 periods); (3) Bio-

sphere (12 periods), and (4). Conservation of Nature (16 periods). The last section on conservation of nature deals with conservation of plants and animals, conservation of air, water resources and soils. It also includes topics in analysis of the causes for disturbance of the normal processes in the biosphere, conservation of natural landscapes, the history of the movement for conservation of nature, the Indian and international efforts in the field of conservation of nature. Based on the theory of the entity of the biosphere, this section "Conservation of Nature" contains an analysis of man's interrelations with nature as well as a consideration on the ways of maintaining our environment in the days to come. The normal balance in nature and consequently the guarantee that life will exist on the earth, depends not only on our understanding of this principle, but mostly on our energetic action towards conservation of nature.

Conservation Education in the School Curriculum in India as spelt out by the Biology Study Groups of the NCERT.

The biology syllabus for classes 5-10 has been prepared by the Study Groups. How the problems relating to "Conservation of Nature" were tackled in the school curriculum is described below.

Finding the situation as described in the introduction of this article, the Biology Study Groups felt that a better impact of the need to conserve natural resources could be emphasised on the minds of the present generation. Therefore, in the curriculum developed by the Study Groups, a greater emphasis is placed on the abounding natural resources available in the country, how these resources are gradually diminishing due to human intervention, and how even day-to-day needs like agriculture production are inter-connected to natural conservation.

In this scheme, an emphasis on an enquiry approach to the learning of biology, to fulfil the two basic needs *viz*, of stimulating an interest in the minds of the young students and also arouse a sense of curiosity, has been given. This has the advantage of bringing about an impression on the availability of vast array of natural resources in the form of flora and fauna in our country. For instance, in Book I, a wide account of plants and animals has been provided, as also an account of how living things are dispersed from one area to the other. In the chapters on "Finding about Plants and Animals" (More than what is presently available as facts) are provided, as background material to children, many salient features of the life, structure and physiological facts about animals and plants. In Book II attempts have been made to indicate how vital processes take place in living things, and how animals and plants feed. In Book III, which has an emphasis on the human species, the relationship of microbes and man is dealt with extensively leading on to personal hygiene and the various aspects of agriculture in our country.

It has been considered by this group that emphasis is best placed up to the age of the 12⁺ (for which books have now been produced for use in the Middle Schools in this country) on a vast array of facts of the availability of vast natural resources and the great limitations that are placed upon such resources, that are available to all of us in the country. With the enquiry approach being emphasized to teach biology, it is not too much to expect, that the young minds would ponder a little more and think clearly on what is available in the country now as natural resources of fauna and flora and how best one can keep it intact.

Taking advantage of the basic structures so built up covering the children of age

groups 10⁺ to 12⁺, a more detailed approach to conservation is attempted in Stage II of the curricular material now being prepared for children of age groups 13⁺ to 15⁺. In this stage, the emphasis is shifted from an indication of the vast area of resources, to a study of the detailed factors of the environment and interactions to the various types of organisms. Book IV in the IInd stage is developed progressively from a study of ecology of life in water through land, through forests, leading to and understanding of the web of life and natural cycle of materials, culminating in a chapter on conservation of biological and natural resources including wild life preservation. The whole series ends in Book VI where the last chapter entitled "Man and Nature" will help to focus attention on man's fight against hunger, disease, death and other ethnological factors. To reinforce these ventures the Study Groups have also invited contributed publications (to be published as a series of ancillary background reading booklets), to serve as adjuncts to the Biology Texts and also for simple reading of many vital facts of biology by men at large. Of the 19 titles projected, 8 cover one aspect or the other of our natural resources of plants and animals, as also the predators that diminish our resources. The contributors to the background series are distinguished men of science in this country in their respective fields.

In contrast to the traditional pattern of presenting a set of facts as *obiter-dicta* on conservation of natural resources and wild life preservation etc. (which will have no meaning if it is conveyed essentially by a textual process), a study of ecology vis-a-vis organisms as a whole and as groups in relation to the different environments in this country, would better highlight, both the potentialities of natural resources that

exist and enable constructive thinking to follow. With this in view the need to conserve resources as are still left with us, in spite of human depredation and encroachment on the natural environment has been emphasised. It should, however, be mentioned that one of the basic aims of the course would be to develop an influence on the mind of the young child to indicate the social implications of biology in relation to every day human needs and the present nature of human activities on the life of other organisms and, how far, a study of physiological ecology could bring about a better balance in nature than what exists at present.

More than attempting to reveal an answer to many of the unknown facts of biology, the curriculum developed by the Study Groups could foster, even as it is, an understanding of the interactions between nature and living beings and inculcate in the younger generation the need and the urgency to face the inevitable choice in conserving the fast diminishing natural resources, if the balance of nature is not to be seriously upset; and the environment be kept in a state of balance (both in the physiological and ecological aspects) based on the need for conservation of the natural resources and the consequent well-being of the ever increasing human species.

Practical Implementation of conservation Education in India.

As was mentioned earlier, Conservation Education is taking root in Indian schools. New textbooks and teachers' guides have been published by the NCERT, and with the assistance from UNESCO experts. The books for the middle school classes are ready and they are being used in about 500 schools in Delhi, and 120 Central Schools all over the country. Besides these, some states like

Andhra Pradesh, Gujarat, Kerala, Mysore, Manipur and Madras have shown interest and have adopted or adapted these materials for experimental teaching. Work is now in progress on the textbooks and teachers' guides for the high schools. The Study Groups have also completed work on middle school materials which have been published and they are now working in high school materials.

All these efforts give us hope that conservation education in Indian schools will be practised on a wider scale. If this process proceeds with faster speed the majority of children in India will have an opportunity to be acquainted with ideas and practice of conservation of Nature. The new generation, in about 10-20 years will be able to prevent the destruction of Nature.

Summary

It is quite obvious that conservation education to be effective must be given to school children. The National Council of Educational Research and Training has achieved this objective by laying emphasis on conservation of natural resources at several places in the biology syllabus for classes I through X/XI.

There have been two variants of the syllabus in middle school, but in both as well as in the syllabus for primary and high schools, special efforts have been made to include topics concerned with conservation of plants, animals, soil, air and water. An environmental approach runs through the entire biology course for the middle school and there are special chapters on ecology for the high school.

The middle school syllabus concludes with an important section on "Man and his environment" which is summarised ecological perspective of the entire biology course.

The high school biology course comprises such important chapters as "populations",

“Ecosystems”, “Biosphere” and “Conservation of Nature”. These themes contain an analysis of man’s interrelations with nature as well as a consideration of the ways of maintaining our environment in future. The normal balance in nature and consequently the guarantee that life will exist on the earth depends not only on our understanding of the principle but mostly on our energetic action towards conservation of nature.

In the other variant syllabus prepared by the Study Groups for classes 5 through 10, the syllabus lays emphasis on the vast array of facts about the available resources and students are made to think through the enquiry approach how best to keep these intact.

In the high school the emphasis is shifted to the various types of organisms. Pupils are led to an understanding of the web of life, the natural cycle of materials, culminating in the topic of conservation of biological and natural resources including wild life preservation. The Study Groups have also planned a series of background books to support the textbooks.

One of the basic aims of the course has been to develop an influence on the mind of the school children to indicate the social implications of biology and to emphasize the imperative need to study the physiological ecology in order to bring about a better balance in nature than what exists at present.

Environmental Education —Its Relevance to The Problems of Rural Areas in North-West Europe

TOM PRITCHARD

Vice-Chairman, Commission on Education,
I.U.C.N.

Deputy Director, (Wales),
The Nature Conservancy, Bangor,
Wales.

THE first regional committee of the Commission on Education was established nearly ten years ago and covers 10 countries in North-West Europe, namely, Belgium, Denmark, Federal Republic of Germany, Finland, Great Britain, Iceland, Ireland, Netherlands, Norway and Sweden. One of its tasks is examining the significance of environmental education in furthering greater

Paper read before the 10th General Assembly meeting of the International Union for Conservation of Nature and Natural Resources, held on Nov. 18, 1969 at New Delhi. Reproduced with kind permission.

understanding of the countryside by adults and young people in this part of Europe.

Several of these countries have environmental and educational problems which are similar, but wide diversity is also encountered; some, such as the Scandinavian states, have relatively small populations and environments that are predominantly semi-natural whilst others, such as Germany, Great Britain or the Netherlands are densely populated and industrialised and with only small areas of landscape that have not been greatly modified from their natural condition

Contemporary Rural Problems

The problems facing rural communities can best be understood if viewed against a historical background of social and environmental changes that have occurred over many centuries, but particularly since the Industrial Revolution of the eighteenth and nineteenth centuries. In the lowlands of western and northern Europe, the evolution of the landscape has, in the simplest of terms, taken the course of forest denudation leading to a pastoral and cultivated landscape, interspersed with human settlements and diminishing remnants of natural forest (Darby, 1956). Before the advent of the urban-industrial environment, much of the European continent was a mosaic of natural features and environments not violently modified from their natural condition, supporting a self-sustaining agrarian economy based on the utilization of natural resources by small local communities. There were enough remnants of prehistoric landscape to enable native animals and plants to survive in fair abundance. Human beings were still closely governed by natural forces and obliged to recognise and respect the limitations these placed upon them. The industrial revolution and the growth of large urban centres (especially in

the lowlands of northern Europe) were the most violent and far-reaching impact the landscape has ever suffered from mankind. The urban-industrial impacts were threefold.

First, they changed the basis of the rural economy over wide areas; agrarian settlements could no longer survive as self-sustaining communities but became obliged to provide the food and to exploit other natural resources, such as timber, for the urban populations. The agricultural improvements sometimes called the agricultural revolution of the eighteenth and nineteenth centuries were a direct result of pressures from the urban areas for food, timber and other products of the land. Even in the Scandinavian peninsula, where urban-industrial growth occurred only on a small scale in comparison with, say, Germany and Great Britain, heavy demands on timber for export and charcoal for local industries, such as smelting of iron ore, resulted in exploitation of natural forests. In the lowlands further south Denmark, Netherlands and parts of Germany, Britain and Belgium, forest was usually replaced by fields used for diversified, rotational agriculture. Large stretches of marshland and peat bog also disappeared when drainage became possible with the spectacular advance in mechanisation. In the Netherlands, civil engineering not only transformed the landscape but created entirely new lands from the sea.

Secondly, there were population increases due to socio-economic factors, and particularly as a result of progress in medicine leading to prolongation of the life span and decrease of infant mortality. These intensified the demand for food and living space.

Thirdly, industrialisation led to massive exploitation of natural resources and to physical damage to the landscape, either through operations such as coal-mining and quarrying or by pollution of land, water

and air arising from the need to dispose of the solid, liquid and gaseous waste products of industry.

Soil erosion, as a consequence of these impacts and of over-grazing and other practices has accelerated rapidly during the last two centuries. Regulation of water courses and creation of reservoirs to provide water supplies and to generate electricity have caused radical changes to the physical (including hydrogological) and biological features of the landscape. Some streams and waterfalls have disappeared, the character of water catchment areas has changed.

The process which began in the eighteenth century is still accelerating and urban-industrial developments nowadays have an overwhelming influence on much of the European environment even in very remote rural areas. Urban populations are growing, while those of the rural areas are in many places decreasing. For example, at the end of the seventeenth century, 95% of the people of Britain lived in rural areas and were engaged in agrarian work. Today, 95% of the British live in towns and cities, only the remaining 5% are concerned directly with producing food and they, in spite of being aided by exceptionally advanced agricultural techniques, are able to produce only half the country's total requirements (Stamp, 1955). Similar changes in the social pattern have occurred in the other countries also. The growth of population and raised standards of living, both of which have become particularly pronounced in the last quarter of a century, are creating unprecedented demands for space. Agricultural land has to be covered with houses and factories and the value for recreation of the less productive areas is rising annually, with the result that more and more of what remains of natural or semi-natural areas is being utilised in one

way or another. More prosperity means more leisure, and leisure is closely linked to obtaining more facilities for travelling, usually by car. For various reasons, it is the more attractive, uncultivated places which draw majority of people, and rural areas largely ignored in the past are now penetrated by the public. The growing number of automobiles require new highways and existing ones are also having to be improved. Furthermore, people from the urban centres are travelling much longer distances for recreation and tourism, reaching as far as northern Scandinavia and the Mediterranean. Even on day visits, national frontiers are often crossed.

The demand for land and water, especially mountains, lakes and coastal areas, for recreation effects each of the countries, but means of providing this need, as well as the pressure of urban and industrial development, agriculture, forestry and other traditional land uses, vary considerably. Furthermore, rapid changes are taking place in the status of agriculture. Multi-purpose use is becoming widely accepted as a basis for land utilization policies. In Sweden, the area of agriculture land is being reduced by extension of forests which are developed also for outdoor recreation. In Britain, marginal agricultural land in the uplands is often afforested, and new measures are being adopted, such as by Rural Development Boards, for a more integrated approach to land use, including provision for landscape conservation and recreation as well as for agriculture and forestry, while in the lowlands intensive and highly efficient agriculture still dominates. In the uplands of the Federal Republic of Germany and Belgium, similar opportunities exist for creating new patterns for the development of the countryside. Iceland, Norway, Finland and northern Sweden are still predominantly forest, peat

bogs, lakes and tundra, where utilisation of natural resources in terms other than kilos or calories is a major challenge. They are the major "natural areas" in northern Europe, still with enormous potential for tourism and recreation.

Quite apart from the effects of the leisure seeking public, other major changes have been brought about by urban and industrial development. Pollution is still a prominent problem. Although remarkable progress has been made to devise techniques to minimise its effects, many rivers are virtually devoid of life, fertile fields have been converted into deserts by toxic industrial wastes, and landscape and people affected by air pollution. In the larger industrial countries pollution is a long-standing problem; but it is increasing alarmingly in areas previously little affected, such as the far north. For example, in Sweden and Finland there has recently been severe public reaction to mercury pollution from timber industries which has had very visible effects in water courses in these countries with a strong angling tradition. Pollution from industry, sewage and oil spillages are also seriously affecting the marine environment, particularly the Baltic and the North Sea. The wreck of the giant oil tanker, "Torrey Canyon", off the south coast of England, has highlighted the disastrous consequences of marine pollution.

Even in those rural areas, where industry has no direct physical effects, the progress made in the use by farmers of chemicals as fertilisers and pesticides has brought about irreversible changes in the environment. Water course and lakes have been enriched with highly soluble chemicals in fertilisers, changing probably for ever, their chemical and biological composition. Wildlife populations in some places have been modified radically by the selective effects of pesticides which have penetrated their ecological

system. Modern forestry is often monocultural, plantations of exotic trees uniformly covering large areas which were previously clothed with varied woodland rich in native species.

Challenge to Educationalists

These patterns of change in the human environment and the underlying sociological economic, physical and biological factors have been the subject of much study during this century, and techniques for improving the management of natural resources developed for a wide range of circumstances, especially in Europe and North America. However, there is still widespread dissatisfaction among natural resources experts (and, increasingly, the public at large) with the extent of environmental mismanagement which is reflecting the fact that the knowledge available is not, in many circumstances, being applied to the solution of the problems. The reasons for this are manifold, and familiar probably throughout the world. In some instances, they are of a financial nature; in others, they are political or administrative. But it is fairly obvious that the basic problem is insufficient public awareness of the relationships between man and environment, arising from inadequacies in education systems. Misuse of natural resources occurs largely because people have been inadequately educated to realise the need for environmental care. Communities have been uncaring and unprepared to demand high standards of environment. Their leaders have been unable, or unwilling to recognise the problems; or they have been ill equipped to secure expert advice towards finding the solutions. Nevertheless, some communities have demanded high standards and assistance from trained environmentalists. Thus, there are examples of achievement to provide a basis for the extension of sound practices on a wider scale.

It is hardly necessary to stress the importance of environmental education as a key to open the door to an understanding of the political, economic and technological power which the highly developed nations of Europe can wield, to their benefit or otherwise, in the process of wresting their basic needs from diminishing natural resources. Such education should go further than to create an awareness, or even an understanding of man's relationship to his environment. It should indicate how to conserve natural resources, remembering that conservation involves matching the use of such resources to the changing demands of human populations. In other words, the concept of the use and care of the environment should become an integral part of modern culture. This is brought out very effectively in the Council of Europe's recent report on "Regional Planning, a European Problem" (Council of Europe, 1968).

Those concerned about the conservation of natural resources believe that relevant educational progress has been insufficiently rapid. Until recently, there has been inadequate communication between environmentalists and educationalists, and few efforts have been made to define the need in precise educational terms and to relate educational terms and to relate educational objectives to environmental matters. In the decade, encouraging progress has been made in diagnosing the elements in education programmes that are relevant to the environment and in analysing the principal features of this environmental education and its function in a modern society. Inquiries and discussions by interdisciplinary groups such as by the British Study on Education and Field Biology (1963) and the IUCN's North-West Europe Committee (Pritchard, 1968, unpublished) have helped to clarify the needs in practical terms. The phrase 'environmental education'

is now finding a place in the educational vocabulary, and some educationalists are recognising its fundamental precepts and consequently their cognate responsibilities.

The impetus for environmental education springs from a recognition of two important issues. First, young people seems to have a latent interest in their environment, and especially in its natural features, which, if cultivated, can develop into an understanding of natural phenomena and an appreciation of cultural and aesthetic values which will bring personal enjoyment and satisfaction in later life. Secondly, since human beings inevitably exploit natural resources, they require an understanding of the means of doing so without unnecessary wastage; conservation, although in practice entailing technical and scientific disciplines; is essentially a wise attitude towards the use of the human environment. Those guided towards such an attitude can be expected, individually and collectively, to have more concern about the use of the resources of the earth to improve their living conditions in cultural and aesthetic, as well as material, terms.

There is a danger in all developed countries that technological education to sustain and improve material standards of living will not be matched by sufficient preparation for the appreciation of cultural and aesthetic values. Vigorous technological advance in Europe, coupled with the streamlining of marketing techniques for rapid consumption of mass-produced goods, is bringing about unprecedented economic and social changes, and the majority of people seem likely to continue to have wealth and time to spare for leisure and recreation. Although training to prepare people for work must continue to be one objective in education, a second one, surely of equal importance, should be to prepare people to make creative and enjoyable use of their leisure time. Much of this

leisure is intricately related to pursuing outdoor activities in the countryside.

The relentless, and formerly unorganised and unplanned, growth of industrialisation in Europe has created a most complicated urban-based society, with an urban culture far removed in attitude and behaviour from that of previous centuries. Until recently, few people in towns and cities have had either the time or the inclination to think about, let alone appreciate, the qualities of the human environment. Thus the need to respect the environment has just begun to be accepted as a major factor in modern living. It may be supposed that this has been brought about by increased opportunities for people to experience different and better environmental conditions than they had previously been accustomed to. The mass exodus of people from townscapes of brick, concrete and tarmac into the countryside is giving birth to popular demands for national parks and conservations of the countryside and its wild life. Urban people are showing concern about the management and development of rural areas for their own benefit as well as that of country dwellers. Thus, some of the traditional barriers between town and country are breaking down. This will surely lead to greater interaction of urban and rural cultures, provided these trends are recognised in educational circles and allowance made for them in education programmes.

Regardless of the extent to which integration of these cultures will proceed, some people will continue to live and work in the countryside and the urban dwellers will continue to have their effects, directly and indirectly, on the life of rural communities and on the form of the landscape. Educationally, there are some specific objectives to be met for the two groups, over and above the creation of environmental awareness in society as a whole.

But these objectives involve emphasis rather than subject-matter and methods of teaching or other means of imparting knowledge. Few educationalists would contemplate creating a sharp distinction between their basic educational objective in urban and rural areas. It is for this reason that, while this paper is specially concerned with the problems of rural areas, it would be unrealistic to concentrate exclusively on the education of people who live in the countryside. Nevertheless, certain special points about the needs in the two communities can be distinguished and these are referred to below.

Educational Needs of Country Communities

Education can extend the scope for a greater participation in countryside planning and development by the rural community as a whole, and encourage a deeper understanding of the economic significance of conservation to the people who live and work in the countryside. Protecting natural features and consciously developing an aesthetically acceptable countryside results in a higher monetary value on individual properties and in maintaining a flow of tourists and others from the towns who contribute to the rural recreation economy. This is particularly important in upland areas along the coast, and near to or in National Parks, where tourism and recreation are contributing an ever growing income supplementing agriculture and helping to arrest rural depopulation in many parts of Europe.

Agricultural and silvicultural technology is changing rapidly and influencing the environment often in obscure but far-reaching ways. For example, use of pesticides and chemical fertilizers calls for education and training of farmers and their staff to reduce accidental or ill-considered actions such as pollution of water courses and to indicate

the reasons why special care should be exercised near to vulnerable areas of importance for the conservation of wild life, such as nature reserves. Then, the consequences of drastic reshaping of the landscape, such as by removal of hedgerows, drainage of wetlands, afforestation without due regard to visual amenity, and the design and siting of farm buildings, often needs more informed consideration by the farming community.

Education of Urban Dwellers

This is a much more complex problem because urban dwellers constitute a much larger, more varied part of the European population. They affect the countryside directly by their individual behaviour when they visit rural areas for recreation, and indirectly through the pressure which their political, legislative, industrial, technological and commercial activities bring to bear on natural resources.

Regarding their recreational needs, much of the education and information required is provided by various official and voluntary bodies connected with conservation. There are nature trails, information leaflets, talks, films, television and radio programmes and other means of enabling young and old to appreciate landscape, farming, forestry, wild life and its conservation, and rural life generally. There are also codes of behaviour, wardening schemes, byelaws, planning techniques and other means to develop patterns of human behaviour compatible with countryside conservation.

Incorporating knowledge about rural problems into the decision-taking processes of urban society is a much longer-term task and has to be undertaken largely in the educational institutions. Statesmen and civil servants, planners, landscape designers, technologists and scientists, and several

other professional groups need to be informed of the changing problems and the impacts they are potentially able to have on them. (The stroke of a civil servant's pen, a decision in a boardroom, or a drawing on a desk, are known to have had devastating repercussions in places never seen, let alone understood, by the people concerned). This is recognised by leading educationalists as one of the vital functions of environmental education. In some cases, such education forms a part of the liberal studies of professional people; in others, such as for planners and landscape designers, it is becoming an integral component of their training, usually in the form of applied ecology.

Summary

Examining the significance of environmental education in furthering greater understanding of the countryside by adults and young people in North-West Europe is one of the tasks of the first regional committee of the Commission on Education established nearly ten years ago and covering 10 countries in this part of Europe.

The industrial revolution and the growth of large urban centres (especially in the lowlands of northern Europe) constituted the most violent and far-reaching impact mankind has ever inflicted upon the landscape. They changed the basis of the rural economy over wide areas, population increased owing to socio-economic factors, industrialization led to massive exploitation of natural resources and to physical damage to the landscape. The process which began in the eighteenth century is still accelerating and urban-industrial developments have an overwhelming influence on much of the European environment even in very remote rural areas. The leisure-seeking public penetrates attractive, uncultivated places and also rural areas

largely ignored in the past. Quite apart from the effects of the leisure-seeking public, other major changes have been brought about by urban and industrial development. Pollution is still a prominent problem. Even in those rural areas, where industry has no direct physical effects, the progress made in the use by farmers of chemicals, fertilisers and pesticides has brought about irreversible changes in the environment. Modern forestry is often monocultural.

In spite of some profound study of these patterns of change in the human environment during this century, there is still widespread dissatisfaction among natural resources experts (and, increasingly, the public at large) with the extent of environmental mismanagement which is reflecting the fact that the knowledge available is not, in many circumstances, being applied to the solution of the problems. Apart from the financial, political or administrative causes of this state of affairs it is fairly obvious that the basic problem is insufficient public awareness of the relationships between man and his environment, arising from inadequacies in education systems.

It is hardly necessary to stress the importance of environmental education as a key for opening the door to an understanding of the political, economic and technological power which the highly developed nations of Europe can wield, to their benefit or otherwise, in the process of wresting their basic needs from diminishing natural resources. Such education should go further than to create an awareness, or even an understanding, of man's relationship to his environment. It should indicate how to conserve natural resources, remembering that conservation involves matching the use of such resources to the changing demands of human populations. In other words, the concept of the use and care of the environ-

ment should become an integral part of modern culture.

Hitherto, educational progress has been insufficiently rapid. In the last decade, however, there has been an encouraging leap forward and the phrase "environmental education" is now finding a place in the educational vocabulary, and some educationalists are recognizing the fundamental percepts and consequently their cognate responsibilities. Young people seem to have a latent interest in their environment, which if cultivated, can develop into an appreciation of cultural and aesthetic values. Since human beings inevitably exploit natural resources, they require an understanding of the means of doing so without unnecessary wastage. Conservation, although in practice entailing technical and scientific disciplines, is essentially a wise attitude towards the use of the human environment.

With the huge urban development, the need to respect the environment in Europe has just begun to be accepted as a major factor in modern living. Some of the traditional barriers between town and country are breaking down. This will surely lead to greater interaction of urban and rural cultures. Few educationalists would contemplate creating a sharp distinction between their basic educational objective in urban and rural areas.

In the country communities, education can extend the scope for greater participation in countryside planning and development by the rural community as a whole, and encourage a deeper understanding of the economic significance of conservation to the people who live and work in the countryside.

The education of urban dwellers is a much more complex problem because urban dwellers constitute a much larger, more varied part of the European population

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In the preparation of this paper the author has liberally drawn on the knowledge and experience gained by the North-West Europe Committee of IUCN, and particularly on the report on environmental education he submitted to the Council of Europe in 1968. Special thanks are due to Mr. P.H. Oswald, the Secretary of the Committee, for his invaluable help and constructive criticism of the manuscript,

Chemistry and Conservation of Nature

PROF. S. A. BALEZIN, UNESCO
CHIEF TECHNICAL

Adviser,
NCERT, New Delhi

WE are living in the midst of a rapidly increasing scientific and technological revolution. Everyday we hear of the completion of construction of new blast furnaces, chemical factories, power stations, the development of new powerful machines, etc. In this progress, chemistry plays a special role and chemical industry helps to meet the requirements of society ranging from common salt to synthetics, clothing and man-made food.

Though the scientific and technological progress of the industry of our century is becoming ever more rapid, the "food" for it still comes from the natural resources—above all water, the resources of the earth and all that can grow and develop on our planet. In spite of the fact that the water resources on earth are limitless, the human community is already experiencing and will increasingly be experiencing a shortage of fresh water.

The clear air our ancestors breathed is at present polluted in big cities and industrial centres. Water, air and soil are essential necessities for everything that grows and

lives on the earth. However, the rapidly developing chemical industry and related industries along with the benefits they are increasingly giving to mankind also produce waste which pollutes the air, water and soil. A particularly dangerous threat to living nature is the development of atomic power generation and the development of the industrial production of modern polymeric materials.

The atmosphere of the larger cities such as New York, London, Paris, Moscow, etc., is being polluted by the discharged gases of the motor cars and the "fumes" of the industrial enterprises. Thus, in New York upto 3,200 tons of oxides of sulphur (which in terms of sulphuric acid equals to 5,000 tons), 230 tons of dust and 4,200 tons of various gases are discharged into the atmosphere daily. In Los Angeles the atmosphere of the city streets becomes polluted by 12,000 tons of chemical wastes, mainly oxides of nitrogen and carbon mono—and dioxide. The acceptable concentration of carbon monoxide is $4\text{--}5\text{ mg/m}^3$ whereas in many big industrial centres and cities it reaches $200\text{--}800\text{ mg/m}^3$ —thus exceeding by tens of times the acceptable norms.

While such gases as carbon monoxide, sulphur dioxides, oxide of nitrogen and hydrogen sulphide affect man and animals immediately as poisonous substances, the dust in the air pollutes it and at the same time carries various micro-organisms causing severe diseases in man and animals.

The greatest damage in recent years has been caused to the water reservoirs of the earth and above all to the rivers and lakes. Recent news about a large scale poisoning of fish in the River Rhine and the death of birds on the English Coast has caused grave alarm for all the people on the earth.

Everyday, rivers are polluted with the products of the petroleum industry and

crude oil during transport. The so-called water wastes from various industrial enterprises discharged into water reservoirs escape calculation. Suffice it to point out that only two soda producing factories of medium capacity discharge easily upto 3 million tons of wastes containing common salts, ammonium chloride, carbonic acid and other substances in solid state. Upto 10,000 tons of water is needed to rinse only one thermal power station. This water is then discharged polluted with organic and inorganic acids and oxides of iron, calcium and other metals.

Enormous stream of water wastes not only pollute water and make it useless for the living organisms but they also spoil the soil changing the pH of the soil solutions.

The sediments of the water wastes also serve as good food for micro-organisms and viruses.

The rapid development of the polymer materials industry is inevitably connected with the so-called discharge gases, one of which is hydrogen chloride. Rough estimates show that in the USSR alone the plants producing industrial polymers discharge, in terms of hydro-chloric acid, upto 8.5 million tons of hydrogen chloride while the maximum amount of hydrochloric acid necessary for the economy of that country is not more than 0.5 million tons. Millions of tons of hydrochloric acid have to be "discharged". But the question is where?

Pink orange clouds of "smoke" are discharged by the plants producing nitric acid, the amount of which is ever increasing. These beautifully coloured wastes containing oxides of nitrogen poison the air and water and kill plants and animals.

It is difficult to realize the scope of the disaster mankind is facing due to the development of atomic power generation. Suffice it to say that according to

scientists 'and engineers' forecast, an atomic power station with the capacity of 10 million kilowatts will be commissioned daily starting from the year 2000.

The problems of the disposal of the radioactive wastes of the atomic energy plants is yet far from being solved. The gases in the air, the pollution of the water, the salination of the soil and the changing pH of the soil solution not only poison and spoil nature but also drastically disturb the equilibrium in nature.

The human community is under the threat of a catastrophic destruction of nature. One would think that under such circumstances literally every human being on our planet should realize the scope of the impending disaster and begin to realize it while still a child and be aware of at least the most elementary measures aimed at the conservation of nature. However, to our greatest regret and disappointment, school textbooks of chemistry and physics provide the children with no information on this question. And this is so when almost any topic of the chemistry course starting from the middle school level provides material connected with the conservation of nature. Take, for example, such topics in the middle syllabus as burning of oxygen, water, carbon dioxide, preparation of sulphuric and hydrochloric acids and their salts.

At the level of the high school such topics would be: nitric and phosphoric acids, alkalies, blast furnace, production of metal, preparation of soda, polymers electrolysis and others. In other words while studying chemistry, it is necessary to know, along with the benefits that chemistry gives, the destructive effects on nature caused by chemistry and chemical industry.

The question arises: Given modern industry, is it at all possible to breathe clean air, have clean water in the water reservoirs

of the planet, avoid salinating the soil and disturbing natural equilibrium? The question should be answered categorically: yes, it is possible.

Modern technology makes it possible to eliminate the harmful effects of the discharged gases by means of the so-called catalytic completion of their burning with subsequent absorption of carbon monoxide and other gases. Technologically it is also possible to catch the smoke being discharged by various furnances and at the same time to extract the valuable products contained in the fuel gases.

Ion exchange installations can automatically clean the water wastes of any industrial enterprises.

The problem of disposal of the products of atomic energy can be solved in principle by using outer space or one of the neighbouring planets.

Rough estimates show that the expenses on the measures to be taken to conserve the air, water and soil and consequently plants and animals will be fully compensated by using the products obtained from the processed wastes. Thus, the fuel gases of many industrial enterprises contain valuable metals the extraction of which will make up for the expenses incurred to extract them. This, of course, is just an outline of the possible ways of the conservation of nature.

All this information should be provided to the children of the school age in comprehensible forms and in accordance with the level of their knowledge. The utmost necessity of this information for the rising generation is obviously beyond any doubt.

Along with this, it is necessary through UNESCO and National Organizations to familiarize the population extensively with the impending threat of destruction of the natural wealth. This can be done through lectures, publication of popular

science books, pamphlets and brochures. Evidently the time is ripe for serious scientific research on the conservation of nature on this planet. The funds spent on one experimental explosion of an atomic bomb could cover one year's expenses of a research institute.

The system of education at the school level is of great importance in the cause of propagating measures for the conservation of nature. "The time has come", writes the French Scientist, A. Ducrog, "to acquaint children as early as possible with the modern achievements of science. Science education is necessary for all people. As everybody needs the knowledge of traffic rules today, tomorrow they will have to know the speed of light, what the volt and watt are and what the distance from the earth to the Sun is.

Similarly we could say that children must know not only the fundamentals of modern production but also their effect on the surrounding nature. All this is possible if the children study, beginning from the middle school, systematically, the science disciplines of chemistry, physics, biology and mathematics on a compulsory basis.

What is said above enables one to draw the following conclusions:

- (a) A systematic study, on a compulsory basis, of chemistry, physics and biology as individual science disciplines for all children of the school age.
- (b) Inclusion in the syllabi and textbooks of the topics connected with the conservation of nature as obligatory material.
- (c) Wide propagation of the measures on the conservation of nature.
- (d) Organization of research on the development of methods of conservation of nature.

With these objects in view the textbooks of biology, chemistry and physics, being developed under the UNESCO Secondary School Science Teaching Project in India, include information on the conservation of nature. I shall just mention a few instances from the course of chemistry. Thus while studying the chapter on water, consideration is given to the modern methods of purifying water, both natural and water wastes of the chemical plants. In the topic "electrolytic dissociation" ionides and their use for purification of water are studied as well as extraction of metals from water wastes. Considerable attention is given to various methods of catching dust. When the structure of the atom is studied both in the course of chemistry and the course of physics, attention is drawn to the role of the energy released

in atomic fission and fusion and its effect on the living organisms. It should be noted that introducing in the textbooks of chemistry, questions connected with the conservation of nature is just the first attempt. Instructional materials should be further improved in that direction.

The question of the conservation of nature has at present become the common not only of individual scientific organizations and institutions but the concern of the wide public beginning with education at the school level.

The problem must be solved on a global scale. It is only through the combined efforts of the engineers, scientists and governments that the impending destruction of the natural wealth of our beautiful planet could be thwarted.

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Notes on Conservation and Environmental Education

JONATHAN HOLLIMAN

International Youth Federation for
Environmental Studies, U.K.

CONSERVATION is the recognition by man of his interdependence with his environment and with life everywhere; and the development of a culture which maintains that relationship through policies and practices necessary to secure the future of an environment fit for continued life and a sustained yield from natural resources.

Environmental education is the process of creating an awareness and understanding of the biophysical environment, its necessity for man's cultural, spiritual and material welfare and the need for its conservation and rational development.

Environmental studies include all studies related to the environment such as biology, geography, geology etc., and its emphasis is on the unity and inter-relations of man, environment and resources.

The need for environmental education is adequately expressed in a resolution adopted by the United Nations General Assembly, 3rd December 1968. Environmental education is necessary "because of the continuing

and accelerating impairment of the quality of the human environment caused by air and water pollution, erosion and other forms of soil deterioration, waste, noise and secondary effects of biocides, accentuated by rapidly increasing population and accelerating urbanisation. Because of the consequent effects on the condition of man, his physical, mental and social well being, his dignity, and his enjoyment of basic human rights. Because increased attention to problems of the human environment is essential for sound economic and social development. Because intensified action is needed to build, and where possible, to eliminate the impairment of the human environment. Because a frame work for comprehensive consideration of the problems of the human environment is needed to focus the attention of governments and public opinion on the importance and urgency of this question. Because the risks inherent in the uncontrolled application of modern technology are very real and very frightening; because there is an environment crisis."

This is now recognised by many educationists, politicians and international agencies, such as United Nations, as a major world problem. UNESCO have begun a large International 'Man and Biosphere' programme and the United Nations is preparing for the 1972 conference on 'Problems of the Human Environment.'

Environmental education is increasingly becoming integrated into the formal education system especially in western Europe and the USA where conservation needs and problems are immediate. Most universities and colleges in the USA, for instance, have graduate conservation and ecology programmes. In the U.K. there are now nine university departments of Environmental Studies for undergraduates and environmental studies will be developed in

nearly every Primary school in the U.K. in the near future. Large numbers of colleges already provide the necessary teacher training.

At the school level environmental education has two main aspects. Firstly environmental education involves subjects concerned with the biophysical environment with an

emphasis on interrelationships between living organisms and their environment and the need for rational use of the environment. Secondly environmental education involves the use of the biophysical environment in the learning process. Some syllabi are based almost entirely on outdoor studies, projects on a school forest plot or garden.

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Science Nobel Laureates of 1969

R.K. DATTA

Beth Israel Medical Centre,
New York.

HOW does a virus reproduce and what is its genetic structure have been the subject of active research for last 30 years for Drs. Max Delbruck, Salvador Luria and Alfred Day Hershey. They have recently been chosen as the joint winners of 1969 Nobel Prize for Medicine or Physiology. How do compounds take on geometrical configurations in space and how these three-dimensional configurations determine the properties and the course of chemical reactions? The stereo chemistry of cyclohexanes, steroids and terpenes has been research of two chemists, one Norwegian and one British, Drs. O. Hassel and D.H.R. Barton who have been named as co-reipients of the 1969 Nobel Prize for Chemistry. How does the interaction of subatomic particles produce energy has been the research of Dr. Murray Gell-Mann. He has been chosen to receive the 1969 Nobel Prize for Physics.

Dr. Delbruck

Dr. Delbruck, 63-year-old Professor of Biology at California Institute of Technology, Pasadena, discovered the reproductive process known as replication of a type of virus called bacteriophage, which infect bacteria. Upon infection of a bacterial cell by a bacteriophage, virus, the bacterial cell undergoes

drastic metabolic changes, becoming a new entity. The new metabolic activities taken over and dictated by the invading virus, lead in minutes, to the formation of new generations of virus particles. The replication mechanism first demonstrated by Dr. Delbruck with bacteriophage is now recognized as the replication pattern of all viruses. German-born Dr. Belbruck who started his career as a physicist and is also known for his earlier work on quantum theory of chemical bonds, moved into the field of virology in his mid 30's and developed the plaque technique now in use for identification and purification of viruses. He is also known for his work on mutation of drosophila and the nature of sensory transducers that carry impulses to the brain. Young Delbruck received his education in the University of Gottingen, getting his Ph.D. degree in Physics in 1930. He worked as a Rockefeller Foundation fellow in Physics in Copenhagen and Zurich. Upon migration to U.S.A. he resumed the same fellowship in Biology at California Institute of Technology (1937-40). Having served as an instructor of Physics at Vanderbilt University (1940-45) he joined the present institute in 1945, eventually becoming its associate professor (1946-47) and professor since 1947.

Dr. Luria

Dr. Luria, Sedgwick Professor of Microbiology at Massachusetts Institute of Technology, Cambridge, is credited with being the first to discover mutation in viruses and renowned for his other work on microbial genetics and biological effects of radiation, was born in Turin, Italy, on August 13, 1912. He was graduated from the University of Turin in medical sciences in 1935. Having worked in the Curie Laboratory of the Institute of Radium (1938-40) he migrated to

U.S.A. to work in bacteriology in Columbia University (1940-42). He served as professor in Indiana University (1943-50) and University of Illinois (1950-59) and joined the Massachusetts Institute of Technology in 1959. He is a non-resident fellow of Salk Institute of Biology and was the president of American Society of Microbiology (1967-68). Recently, Drs. Delbruck and Luria shared the Columbia University's 25,000 Horowitz for their pioneering research in virology.

Dr. Hershey

Dr. Hershey, 60-year-old Director of the Carnegie Institution's Genetics Research Unit at Cold Spring Harbour, Long Island, New York, established in 1952, using radioactive sulphur and phosphorus, directly and unequivocally that DNA was the substance of heredity which, in the case of bacteriophage, upon entering the bacterial cell provided the genetic information for replication of the invading virus to proceed. Also renowned for his other works involving genetic mapping of viruses and bacteriophages and the chemistry of DNA Dr. Hershey received the Lasker Award in 1958. Born in Michigan on December 4, 1908 young Hershey received his Ph.D. degree in Chemistry from Michigan State University in 1934. He spent the next 16 years in Washington University at St. Louis. He joined the present institute in 1950 and became its director in 1962

Dr. Hassel

Dr. Odd Hassel, 72, now retired, formerly Professor of Physical Chemistry of Oslo University in Norway, carried out in the 1930's and 1940's pioneering research on the stereo arrangements of six carbon atoms of cyclohexane, a zig-zag-shaped closed-ring hydrocarbon. These atoms in this compound can bend, twist or fold over on another depending on the conditions permitted. Dr.

Barton, in London, followed up these ideas and extended the investigations to large molecules such as steroids and terpenes, with complicated ring systems with biological functions. Their exposition offered explanation as to how two seemingly identical compounds, but different in three-dimensional configurations, reacted differently with a third compound yielding different reaction products. Born in Oslo on May 17, 1897 young Hassel studied in the University of Oslo and got his Ph.D. from the University of Berlin in 1924. Since 1925 he was in the faculty of the University of Oslo, becoming Professor-Director of its Physical Chemistry Department (1934-64). Recipient of numerous medals and honorary degrees from different universities Dr. Hassel is also famous for his contributions in the studies of crystalline and molecular structures of compounds by X-ray and electron diffraction methods, measurement of electric dipole moments and atomic arrangements in weak complexes formed by electron transfer from donor to acceptor molecules.

Dr. Barton

Dr. Derek Harold Richard Barton, 51, Professor of Organic Chemistry at London's Imperial College of Science and Technology, opened the field of conformational analysis in organic chemistry in 1949. The study of how compounds react when their three-dimensional shape is known is called conformational analysis. It is through this analysis that it is quite possible to predict the course of a chemical reaction in organic synthesis. According to his theory the spatial arrangement of phenols and alkaloids can indicate the biosynthetic pathways of many complex alkaloids. Born at Gravesend, England in 1918, young Barton studied in the Imperial College of Science and Technology, receiving his Ph.D. in Organic Chemistry

in 1942. After working for few years as a research chemist Dr Barton joined the Imperial College as an Assistant Lecturer (1945-46) becoming its Professor in 1957. He was made a Fellow of Royal Society in 1954. He got Royal Society's Davy Medal in 1961. In 1953 he was appointed a Professor at Birbeck College of London University and a Professor at the University of Glasgow in 1955. As a visiting professor he lectured in various universities of the U.S.A., France and Ireland.

Dr. Gell-Mann

Dr. Gell-Mann, 40, Professor of Theoretical Physics at California Institute of Technology, was cited for his discoveries into the classification of elementary particles and their interactions, particularly between protons

and neutrons in the atomic nucleus. His recent theory about the 'quarks' the smallest particles of all matter has created stir in the physics of elementary particles. According to Dr. Gell-Mann, all other particles are the excited states of quarks. Born in New York in 1929 young Gell mann studied at Yale University and got his Ph.D. degree in Physics from Massachusetts Institute of Technology, at the age of 22. Having served at the University of Chicago for three years Dr. Gell-Mann joined California Institute of Technology in 1955 and became its Professor in 1956, at the age of 26. Hewas awarded the Heineman Prize of American Institute of Physics in 1957 and an honorary degree of D.Sc. by Yale University in 1959. In 1961 he discovered that the symmetry principle of mathematics could be applied to elementary particle physics.

ELEMENTS OF MECHANICAL ENGINEERING

A Textbook for Technical Schools

by

S.K. Basu

Crown quarto, pp ix+82, 1967

Rs. 3.20

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The Man, the Earth and the Heavenly Bodies

K.C. ADALKHA,

ASTRONAUT Armstrong reported: "The sky was black but it looked like daylight out on the surface, and the surface I looked tan. When you pick up material in your hands it is dark, grey or black. There is a very peculiar lighting effect on the lunar surface which seems to make the colours change. I don't understand this completely. He further reports: "There were two kinds of time, measured by the crew's routine, and the other marked by the ageless rocks of the moon". These observations suggest that the surface at the Tranquility Base is self-luminous.

Synthetic crystals of titanium dioxide have eight times greater dispersive powers than diamond. The moon dust and igneous rocks consist of minute bits of rough and smooth glass and fragments of various minerals. They also contain a high proportion of titanium. Thus, the moon dust and crystalline igneous rocks can be regarded as combinations of several prisms of different materials.

The moon dust behaves like prisms is confirmed by the following phenomenal observations:-

- (a) Astronaut Armstrong reported. "The corona of the sun was visible around the limb of the moon as a gigantic lens-shaped or saucer-shaped light stretching out to several lunar diameters. It was magnificent, but the moon itself was even more so. We were in the shadows, so there was no part of it illuminated by the sun. It was illuminated only by the earth, by earth-shine. It made the moon look like grey and the entire scene decidedly three dimensional".
- (b) Astronaut Edwin Aldrin reported: "The objects would go away with a very lazy motion. If any one tried to throw a base-ball back and forth in that atmosphere he would have difficulty at first acclimatizing himself to that slow lazy trajectory, but I believe he would adapt to it quite readily".
- (c) Astronaut Edwin Aldrin reported: "The horizontal reference there is not all well defined. That is, it's difficult to know when you are leaning forward or backward and to what degree. This fact, made local features on the moon appear to change slope depending on which way you were looking and how you were standing."
- (d) Astronaut Armstrong reported: "The rocks seemed to be coming up at us awfully fast".
- (e) Astronaut Edwin Aldrin reported: "The light was sometimes annoying because when it struck our helmets from a side angle it would enter the face plate and make a glare reflected all over it. Then when we entered a shadow, one would see reflections of our own faces in the helmet and they obscured anything else that was to be seen. Once my face went into a shadow it took may be 20 seconds before my

pupils dilated again and I could see details”.

Einstein predicted the existence of gravitational waves, but it has not been possible to verify this. No available sensitive system could detect the existence of gravitational waves nor any mechanical apparatus has been possible to generate detectable gravitational energy. The reason is quite obvious; how a thing can be detected when it does not exist.

Newton constructed gravitation on the basis of the existence of heavenly bodies, but the data provided by the Apollo flights does not support the existence of heavenly bodies. They are simply consequences of (i) wave phenomena like reflection, refraction, interference and diffraction; (ii) laws of electrodynamics.

Therefore, in conformity with the first idea, of Newton, the spacecraft rises up, up and up under the action of the force applied but when the action of the applied force exhausts due to air resistance, the spacecraft deviates from a rectilinear path, and adopts a falling motion describing a curved trajectory. When it enters the environment of the nucleus of the earth where exists a natural nuclear reactor and from which energy flows to all parts of the earth, it is caught in the grip of waves of rejected steam and duly processed and purified steam. These incoming and outgoing waves keep the spacecraft in a position of equilibrium.

The following unusual phenomena cast doubt on the existence of heavenly bodies.

- (c) The size of the sun (reported by the crew of Apollo-8 as taking a fan shape) as it appears over the horizon of the Sea of Tranquility is thousands of times larger than the sun which we earthlings observe though there is a negligible difference in earth-sun and moon-sun distances.
- (d) At a distance of 240,000 miles or so

from earth, astronaut Cernan described the size of the earth as that of a dime, but earth gives a sharper definition when viewed from the Tranquility Base and its size is thousands of times larger than the one reported by astronaut Cernan.

- (e) The appearance of the Sea of Tranquility under mysterious circumstances. The crew of Apollo-8 in the 7th orbit reported: “We are now seeing the Sea of Crisis coming over the horizon. The sea is remarkable smooth” APOLLO CONTROL: This is phenomenal. Astronaut Anders further reported: “Just to the west of the Sea of Crisis is the Marsh of Sleep, and west of that is the Sea of Tranquility. The Sea of Tranquility is smooth and there are no craters or mountains”.
- (f) Absence of the moon’s horizon before the spotting of the Sea of Tranquility (in case of Apollo-8).
- (g) The crew of Apollo-8 described the view of the sun “very beautiful” To the crew of Apollo-11 it was an eerie sight.
- (h) The crew of Apollo-8 described the moon as a vast, forbidding expanse of nothing. The crew of Apollo-10 described the view of the moon fantastic, unbelievable, and absolutely incredible.

The earth has 6 times more gravitational energy than moon. Why the “gravity assist” does not come from flying close enough to the earth to have the spacecraft accelerated and its trajectory turned by the earth’s gravitation?

The natural reactor system at the nucleus of the earth (Tranquility Base) is surrounded by compacted rocks which act as a thermal and biological shield. The shield in turn is

surrounded by moon dust which acts as a reflector when pressure inside the reactor core is high and reflects the "positive rays" back into the core.

When pressure inside the core is low, the same moon dust acts as a prism and the blue light emitted by mercury atoms inside the reactor core emerges from the moon dust and is dispersed into spectrum. The blue colour of the sky is due to the scattering of blue light by the moon dust (mercury atoms at a low pressure emit characteristic light consisting of only blue, yellow green and violet). Tipping of tube back and forth from one side to another support my views about the existence of a reactor core at the Tranquillity Base.

The following events suggest that the Sea of Tranquillity is a source of intense radio-activity :

- (a) The rolling and wobbling of the lunar modules.
- (b) The jerking of the command ships at the time of docking.
- (c) Great activity of the guidance system.
- (d) Bouncing of the astronauts as they walked around the lunar module.
- (e) Computer problems.
- (f) First increased heartbeat and great activity but thereafter laziness
- (g) Failure of camera batteries and the batteries in the ascent stage of the lunar module.
- (h) The "Snoopy" looked like a snow-storm hit it. The astronauts of Apollo-10 noticed beads of water on a steel rim around the forward hatch. ('Photons' are absorbed only in the presence of water).

The situation with the crystalline igneous rocks is somewhat different. Here the crystals behave as diffraction gratings and the role of "slit" is played by the unit cell of the crystal. The moon dust covering the

reactor system serves as lenses. When light consisting of a mixture of wavelengths emerges from the reactor core and is diffracted by the crystalline igneous rocks with larger grains, the moon dust brings to focus all light travelling in a specified direction and forms a number of slit images in different positions at infinity in the sky, every wavelength in the original light giving rise to a set of slit images deviated by the appropriate angles or in other words, a continuous group of images is formed side by side, i.e., light is dispersed into continuous spectra. These 'slit images' appear to us as stars. That is why, the stars we see make up a tremendous lens-shaped system. Planets are chromatic and monochromatic aberrations and are simply consequence of the laws of refraction.

In diffraction problems some light is always found within the region of geometrical shadow. It was in conformity with this principle, that the astronauts of Apollo-8 observed little white rays radiating from the geometrical shadows casted by the prism-produced illusory craters. The jagged craters illusive in nature cast shadows, which to the crew of Apollo-8, appeared impact—all terraced and rounded off having grey colour and bright interiors during the first 7 revolutions around the condensed rejected steam.

Wild arrays of igneous rocks form themselves into craters when viewed from a proper angle. Their gigantic size is due to the Sea of Tranquillity's intricate environment which finds analogy in the distorted room at the Graduate Centre of the City University of New York.

- (a) Astronaut Armstrong observed a football field-size crater over the pre-selected landing site.

- (b) On the selection of an alternate site for landing, Armstrong reports: "We looked at several and I changed my

mind a couple of times. One would look a pretty good, and then we got a little closer, it would look less attractive. The one we chose was only a couple of hundred feet square, about the size of a big house lot. It was ringed on one side by some fairly good-sized craters and on the other with a field of small rocks". Armstrong further reports: "I thought I would be able to see the rim of West Crater behind the LM but the abrupt curvature of the moon's horizon prevented it". But in an audience with General Phillips, Armstrong discloses he had walked about 200 feet from the moon landing craft when he went behind it.

- (c) Astronaut Edwin Aldrin reports: "We did not have any craters or boulders but there were rocks of all shapes and sizes".

The fission process in the natural reactor system at the nucleus of the earth (Tranquility Base) may be summarised as follows :

Inside the core, the photons (mercury atoms) collide with the nuclei. The nuclei are split into (i) positrons, (ii) electrons, and (iii) rejected steam. The rejected steam condenses and serves as a screen for geometrical shadows projected by the obstructions-igneous rocks. (During the first 7 rounds, the astronauts of Apollo-8 circled the condensed rejected steam). The positrons (positive charge) and electrons (negative charge) released in the process of fission establish electric and magnetic fields. When the negative and positive charges reach the bulged parts of the earth (earth is pear-shaped) the trajectories of oppositely oriented charges begin to turn as a consequent to the decrease in intensity of the fission process inside the natural reactor core at the Tranquility Base. The charges which from an

acute angle with the field "swallow up" those which form an obtuse angle with the field. The 'transitional layer' or the 'spark gap' where the "swallow up" process takes place appears to us as 'sun'.

The positrons and electrons absorbed by the earth collide within the earth's crust thereby annihilating each other and giving rise to photons again saving the conservation laws. The photons (mercury atoms) are transported by conduction to the natural reactor core at the nucleus of the earth (Tranquility Base) where they cause fission and the cycle repeats. It is a cyclic process analogous to recoilless gamma ray emission followed by resonant reabsorption.

The evolution of heat could be regarded as a multitude of sparks that involves movement of electrons from one state or orbit to another, the sort of thing that happens when electrons leap across between the two electrodes of a spark gap.

(b) Energy is radiated when a rapidly moving hot electrically conducting gas interacts with a magnetic field.

(c) When two different metals are joined together at both ends, and one end is heated and the other cooled, an electric current flows around a circuit.

In the atmosphere, there exists a rapidly moving hot electrically conducting gas where according to the astronauts of Apollo-8, the temperature was 6000 degrees Fahrenheit and also a strong magnetic field. In other words, layers of hot and cold air exist in the atmosphere. It is immaterial whether they originate from the nucleus of the earth or some celestial body, but to satisfy the provisions of electrodynamics, they are required to establish electromagnetic field for the radiation of energy and also to produce 'spark gap'.

The sunrise which the astronauts of Apollo-8 described as taking a fan shape

and concentrated haze going away from the 'sun spots' was a reflected image of the fission process occurring inside the natural reactor core. The principles of dispersion state, on emerging from the prism the light is spread out into a fan-shaped beam. The theory of particles' generation states when electron-positron pair is generated, such a pair leaves a characteristics track in the form of a two-prong fork.

(b) Apollo 11 astronauts report there is only 11 degrees of sunrise at the Tranquility Base on the moon. This sun was a reflected image of the 'spark gap'—spark gap which we earthlings call as 'sun'. The moon which we observe is an "electron image"

(c) The earthrise reported by the astronauts of Apollo 10 and 11 at the Tranquility Base was a condensed rejected steam illu-

minated by the light emanating from the natural reactor system. The condensed rejected steam serves as a screen for the projection of geometrical shadows.

Mercury is a wonderful gift of nature. The suggested dose in sixth decimal potency re-establishes the equilibrium and harmonious interaction between the negative and positive charge in every cell of the human living organism thereby restoring the patient to normal health. The suggested dose is never to be repeated.

However, the fundamental problem under consideration is the true identity of the Sea of Tranquility with its surroundings—whether it is nucleus of the earth or some celestial body. The issue, no doubt, will be decided when the crew of Apollo-12 attempts landing near natural turbines.

ELEMENTS OF ELECTRICAL ENGINEERING

A Textbook for Technical Schools

by

S.P. Ray Chaudhuri

Crown quarto, pp 169, 1967

Rs. 4.60

Aims at presenting an over-all view of the major areas in the subject without entering into specialized details required for advanced studies. The text is in simple English and all technical terms have been defined with clarity.

Enquiries:

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New Dimensions in Science Education

(Lessons from U.S.A.)

J. K. SOOD

Regional College of Education,
Ajmer.

AMERICAN National Curriculum Projects in Science present a promising image. Individuals studying these projects in bits are apt to be lost like a pebble tossed into the sea. "Science—a Process Approach", developed by the Commission on Science Education of American Association for the Advancement of Science and "Conceptual Oriented Programme in Elementary Science", directed by Shamos, present alternate approaches to the elementary school science. It raises a significant question: whether to accept the process approach or unifying concepts of science for the curriculum development, or to go in for the middle of the road philosophy. In either case it will be a difficult decision. Similarly, at the higher

secondary stage the question arises: whether to accept the Physical Science Study Committee materials or Harvard Project Physics; Biological Sciences Curriculum Study Yellow Version, Blue Version or Green Version; Chemical Education Material Study or Chemical Bond Approach.

The confusion is superfluous as the essentials of all these different curriculum projects are inherent in the American life and temperament. Americans are adventurous by nature, love variety, get "feel" of the problems and with challenge solve them. They are not satisfied merely by finding solutions. They try to achieve supremacy at the international level. In the thirties, science and technology were not well developed disciplines in America. In 1968 Luis W. Alvarez won Nobel Prize in Physics, Lars Onsager in Chemistry, Hargovind Khorana, Robert W. Holley and Marshall W. Nirenberg for medicine and physiology. The Apollo 11 astronauts, Neil-Armstrong, Edwin Aldrin and Michael Collins created the greatest event of world history by landing on moon.

The launching of Sputnik I on October 4, 1957 challenged American Science and Technical Education. Science Education became a national concern. The challenge was accepted, jointly, by scientists, science educators, psychologists and classroom teachers. All different aspects, beginning from the nature and philosophy of science to classroom teaching were critically reappraised.

This was the beginning of new era in science teaching. New curricula, first for the secondary and later for the elementary level and more recently, for undergraduate level were developed. These efforts were national as well as local in character. Many of them became international in due course of time. Today, research done in science

* Lessons from Britain; paper written by Dr. W.J. Jacobson, Teacher's College, Columbia University, New York, encouraged the author to highlight his experiences of U.S.A. The author expresses his gratitude to Dr. Jacobson for his helpful comments on a draft of this manuscript.

education has no parallel throughout the world. To understand these projects in science curriculum one needs an understanding of research, experimentation in schools, and a variety of these projects.

The purpose of all these efforts was to teach science which is scientifically authentic and intellectually stimulating. Timely publication of *Education and the Spirit of Science* (N.E.A., 1966) reaffirmed the faith and redefined the values of science education. Emphasis was on the development of rational powers of the individual to the full extent and to prepare the scientifically literate individual, who can understand the nature and events of contemporary civilization. Pella, O' Hearn and Gale (1966) have very aptly defined and described the meaning of scientifically literate individual. Such a person is characterized with an understanding of the following:

1. Interrelationships of science and society.
2. Ethics that control the scientist in his work.
3. Nature of science.
4. Basic concepts in science.
5. Difference between science and technology.
6. Interrelationships of science and technology.

These specifications have unlimited implications both for developed and developing countries. Concept of literacy helps in understanding the nature of science by practising the process of inquiry and eliminates the fear of falling in obsolescence. After all the first objective of education is that it serves the future. Knowledge to be of greatest value must be usable beyond the context in which it was learned (Hurd, 1963).

Certain common thoughts stem from

these efforts which are agreeable trends in science teaching.

1. A trend towards more adequate recognition of science instruction as a necessary component of general education (Action for Science, 1959).
2. Teaching science scientifically is the most profound influence, i.e., increasing recognition that processes of science have equal significance along with the concepts of science (Woodburn; Obourn, 1965).
3. Expansion of scientific knowledge demands conceptual scheme approach for the curriculum construction, which also helps in maintaining the integrity of the discipline. Piaget's thinking is also associated with teaching structure of the subject matter. The pedagogical idea is that children should be taught the unified themes of subject matter area, after which they will be able to relate individual items to this general structure (Eleanor Duckworth, 1964).
4. Laboratory experiences which run over a much longer time, perhaps several class periods even weeks to bring completion shall be in vogue (Hurd, 1961).
5. Close cooperation among working scientists, psychologists science educators, and classroom teachers for the development for curriculum materials, experimentation and final writing is needed.
6. There is an urgent need of continuous reappraisal of science content.
7. There is need of effective in-service programmes for teachers so as to keep them abreast with the latest content and technology of teaching.
8. A trend to develop text, laboratory manual, teacher's guide, films, filmstrips and other supplementary material.

9. Role of the teacher is not to disseminate knowledge but to work as a guide or as an organiser of the learning activities.
10. Use of television, teaching machines, programmed materials and other teaching aids shall be of special significance.

Implications for Indian Schools

The aforesaid trends have far reaching implications both at the primary as well as secondary stage. We can hardly escape from these implications. It is better to understand the philosophy of these "new curricula" and utilize the experiences which are "lessons" not only for us but for all concerned with the improvement of science teaching. These trends substantially influence four different aspects of science education.

Science as part of General Education

In the scientifically oriented society all citizens need functional understanding of science so that they may realize the significance of healthy living; faith in the distinctive methods of science in solving problems, and respect in the rational decisions. Secondly, science education shall prepare technical personnel, who can help in harnessing the untapped natural resources. After all, sound and vigorous economy depends on the maximum use of science and its application. Therefore, science should be a part of general education.

Innovations in Science Curriculum

A continuous, sequential science programme from kindergarten through tenth grade, with planned long range objectives is needed. The organization of the content should reflect the "structure of science". Major ideas should be a part of conceptual schemes, as it is one of the effective ways of organizing the fantastically developing scientific knowledge.

Curriculum should not be only for an elite group but it should cater to the needs of all students with different aptitudes, abilities and interest. Even below average students shall meet their demands. Subject matter needs continuous examination and rigorous treatment.

Dynamic approaches to Science Teaching

Processes of science demand inquiry approach where students learn unaided. Teaching shall be on open-ended methodology. Individualized instruction shall get more attention so that children can understand the empirical basis of scientific evidence. The purpose of school is to make children learn, 'how to learn'. Thus preparing a "self learner" or "an automated learner".

Science Teacher as an Innovator

In these situations the role of the teacher shall be of a guide—a person who tries to organize learning situations rather than a disseminator of information. He will be an innovator, searching and presenting new learning experiences.

Understanding the nature of the learner is an essential part of the teacher's personality. He shall be able to interpret the social implications of the continually changing scientific enterprise. Doesn't it demand rethinking in our teacher education programmes?

In India we are trying to propagate the spirit of "new curricula" through Science Summer Institutes. This involves discovery approach on one hand and an understanding of the learner on the other. Today, we should establish sound relationship between teaching programmes in science and the nature of science. This need further elaboration:

Nature of Science

Inclusion of facts and principles of science

are essential in science teaching. But it shall be incomplete without including processes of science. Processes of science shall help the child in understanding the nature of science. After all, "Science is cumulative and endless series of empirical observations which result in the formulation of concepts and theories, with both concepts and theories being subject to modification in the light of further empirical observations. Science is both a body of knowledge and the process of acquiring and refining knowledge (Fizpatricked, 1960).

Science—A Process Approach, prepared under the auspices of the AAAS Commission on Science Education has identified processes of science as follows:

Classifying, inferring, predicting, measuring, communicating, interpreting data, making operational definitions, formulating models.

Therefore, science teaching should include not only facts of science but also emphasize on the processes which help in acquiring the knowledge.

Nature of the Learner

Understanding of concepts, generalizations, and facts of science is necessary. Yet, the development of attitudes and critical thinking are not excluded, understanding of learning theories and development of the child shall strengthen the efficiency of the teacher.

Later half of this century has witnessed the growing influence of learning theories and allied research in science curriculum. Many psychologists have contributed to the field of learning. Thorndike (animal trial and error), Skinner (reinforcement) Pavoly (the conditioned response), Ebbinghaus (the learning of verbal associates), Wertheimer, Kohler and Koffka (insight). Contributions of learning theories help the

teacher in understanding the nature of the child, proper organization of learning experiences and role of motivation. It is being felt that the involvement of children in learning, reward or reinforcement, new exciting experiences, meaningful material, provision of rich and varied environment help the learners positively and makes teaching effective.

Psychologists have contributed to our understanding of how particular kind of learning takes place. Robert M. Gagne views learning as heirarchical, with one step or stage forming the pre-requisite for further learning and for more difficult and complex behaviour. The heirarchical approach has the advantage of forcing the teacher to first decide upon what he expects from the child to be able to do and then to set the conditions of learning, starting from where the child is, so that the desired behaviour can be reached and assessed.

Gagne suggests that sequence is important, because new learning and strong motivation arise from the "proper" presentation and sequence of ideas. Gange believes that "content" and its "order" are the two most important factors in learning and both must be appropriate for the learner (Gagne' 1963).

The work of Geneva School has aroused interest in developmental psychology and the thinking process. Piaget views intelligence as the individual's ability to act in certain ways and perform certain logical operations. For Piaget, cognitive development occurs in substages, stages and periods. How does a child at various stages of cognitive development learn? A few points stem from the studies of Piaget.

Piaget stresses the importance of Child's direct activity vis-a-vis content. The Geneva School, does definitely place major emphasis on direct activity on the part of the child.

Second implication stems from consideration of the stagewise cognitive development. This would imply that activities in the curriculum, be analyzed in terms of logical operations inherent in them, and decisions must be made as to whether or not the child, at some particular age and developmental level, can operate at the cognitive level that the operations demand. It is important that the spacing of learning activities is a very important factor in planning an instructional programme. In other words, Piagetian theory supports the use of the "spiral" curriculum even at the unit stage (Lawery & others, 1968).

Social Implications of Science

The influence of science and technology on society varies from time to time. It is tremendous in this century. In every walk of life an individual needs clear understanding of science. Social implications of this nature were highlighted by Browowski after the Hiroshima disaster. Further, C.P. Snow dramatized the social implications of science by citing examples of rich and poor nations due to proper utilizations of science and consequences for the rich nations if development of poor nations is neglected. Society needs scientifically literate citizens who can take rational decisions for the proper use of science. Hence, science should be taught as a process or way of behaving, influencing the social forces on the formation of attitudes.

Conclusion

A new programme in science education shall provide opportunities for individual work, involvement of children in first hand experiences thereby acquiring abilities needed to become a rational human being. The emphasis on processes of science, developing positive attitudes toward science and society, understanding the relationships of

society and science and an innovator teacher shall improve the science teaching.

Yet much remains to be done when we talk of implementation. Changing the style of teaching, equipping the teacher with new knowledge, preparation of instructional materials, and keen cooperation of society are the problems yet to be solved. Such an approach shall rejuvenate the science courses which are repetitive and superficial in nature, unstimulating and almost devoid of laboratory work.

We need help of the working scientist to upgrade the content knowledge of teachers; behavioural psychologist to popularize the theories of learning; and science educators to experiment with new methods of teaching. Remember! we have to go far and fast. This is the contention of the author that there is no harm in borrowing "the spirit" of these American efforts rather than beginning from a scratch.

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Study of Surfaces

Part III (interface)

L. D. AHUJA,
Chemistry Department
Indian Institute of Technology,
New Delhi 29

AN interface is a boundary between two phases. When one of the two phases is a gas or vapour, the interface is commonly called a surface. Rarely do the molecules of any phase keep to the bulk of that phase. Quite often, there is an interpenetration of one phase by the molecules of the other and *vice versa*, though this penetration may not be more than a few molecular diameters deep. It may be desirable to emphasize that an interface is formed when the two phases are chemically dissimilar, such as between polar and non-polar substances. This applies only for liquids.

One of the most common example of an interface are the colloidal dispersions of one phase into another. Both the dispersed phase and the dispersion medium can belong to either of the three states of matter. Table I gives the important types of colloidal systems (See table I).

Colloids are characterised by the narrow range of the size of their particle which lies between 10^{-5} to 10^{-7} cm. In fact colloidal state is regarded as an intermediate between a true solution and a suspension. In a true

TABLE I

<i>Disper- sion medium</i>	<i>Dispersed phase</i>	<i>Example</i>	<i>Type of colloid</i>
Gas	Liquid	Fog, mist, cloud	Aero sol
Gas	Solid	Smoke, dust.	Aerosol
Liquid	Gas	Froth	Foam
Liquid	Liquid	Milk, rubber, latex, hair. cream, many medicines.	Emulsion
Liquid	Solid	Gels, pastes, fruit jellies.	Sols
Solid	Gas	Pumice	Solid foam
Solid	Liquid	Butter	Solid emulsion
Solid	Solid	Pearls, some coloured Substances	Solid Sol

solution, the particles are not visible, while in a suspension, they can be visibly seen. Though the particles of a colloid cannot be seen with the unaided eye, their presence can be ascertained through an ultra-microscope. Further, molecules in a solution possess those properties which depend upon chemical forces of attraction and repulsion and upon electric charge. The particles of a suspension, on the other hand, exhibit bulk properties such as density, hardness etc. Though colloidal particles do exhibit some bulk properties such as density, viscosity but in the main, forces of a chemical nature govern their behaviour. The reason for this lies in the relative importance of surface volume ratio of a small particle, rather than of the bulk. To give you just an idea, how large the surface area can become, let us take a cube having an edge 1 centimeter long. Let us divide it into smaller and smaller cubes and see how surface area increases.

<i>Length of the edge</i>	<i>Surface area</i>
1 cm	6 sq cm = $(6 \cdot 1^2)$
10^{-1} cm (1 mm)	60 sq cm = $(1000 \cdot 6 \cdot 0.1)^2$
10^{-2} cm (0.1 mm)	600 sq cm = $(1000000 \cdot 6 \cdot 0.01)^2$
10^{-4} cm (0.001 mm)	60000 sq cm
10^{-6} cm (0.00001 cm)	6000000 sq cm
10^{-7} cm (0.000001 mm)	6000 sq metre ($1\frac{1}{2}$ acres).

Effects which are not detectable on a surface of only six square centimeters, become much more pronounced when the same substance exposes a surface area million times larger, for example, solubility of a substance while in the form of a lump and that when the same lump is reduced to a fine powder.

Interfacial Tension

The tension at the interface can be measured in the same way as the tension at a surface. Some of the methods of measuring surface tension illustrate how an essentially molecular property like interfacial tension can be determined by balancing it against the force of gravity, which is essentially a macroscopic property dependant only upon mass. By carefully mixing benzene with carbon tetrachloride, we can get a liquid with specific gravity equal to one. Water drops suspended in such a liquid will assume a spherical shape.

It will be interesting to know as to molecules of which of these two substances will try to concentrate round the water molecule.

The magnitude of interfacial tension of the two phases is a measure of the degree of miscibility. The higher the interfacial tension, the greater the immiscibility. Frequently, the addition of a third substance to two completely immiscible phases, reduces the interfacial tension between them considerably and consequently increases their mutual

solubility and stability. For example, interfacial tension between benzene and water is 35 dynes/cm. One can see two separate layers. Addition of a small amount of sodium oleate reduces the value of interfacial tension to only 2 dynes/cm, thus making the emulsion of benzene in water quite stable. Conversely if the third substance is more soluble in one than in the other, it can make two completely miscible substances separate into two phases. An interface is much more sensitive to impurities as compared to the surface. You may ask, how does this third substance arrange itself at the interface. Obviously, it is to satisfy two suiters. In the case of sodium oleate, probably the Na side points towards water and the oleate side towards benzene. The molecule does not get ionised as it resides only on the surface and the bond cannot be broken by the low dielectric of the surface.

Miscibility and Interfacial Tension

There is a direct relation between miscibility and interfacial tension. The higher the interfacial tension, the lesser the miscibility. For example, the interfacial tension between benzene and water, the two practically immiscible liquids is 35 dynes/cm, whereas that of water and ethyl alcohol is nil, as they are miscible in all proportions.

An interesting aspect of this relation is the existence of critical solution temperature. Certain pairs of substances (phenol and water) are miscible in all proportions, only above a certain temperature called the maximum critical solution temperature, while others (trimethyl amine and water) are miscible in all proportions only below a certain temperature called the minimum critical solution temperature. There are yet a third class of substances (nicotine and water) which are miscible in all proportions both above and below certain critical temperatures. In the intermediate range, they separate into two layers.

These critical solution temperatures are very susceptible to the presence of even traces of impurities. They are widely used in the petroleum industry for an approximate knowledge of the aromatic content of hydrocarbons. It is known by the name of Aniline Point.

Colloids

I have already quoted colloids as an important example for studying the properties of an interface. This intermediate state has peculiar properties of its own, such as undetectable colligative properties, easily visible turbidity, negligible diffusion rates etc.

In a colloid, two properties play the major part—the size and the charge. When we reduce the size of a particle to microscopic limits, the unsaturation of bonds at the surface is so large that the field of surface forces makes its influence felt. For example, whereas ordinary ions in a solution have one or few electronic charges, colloidal ions have hundred or thousands of them. The result is stronger electric forces preventing complete dissociation.

The presence of charge on colloidal particles can be very easily demonstrated by observing the relative motion of a boundary

under the influence of applied potential.

To avoid gas evolution at the electrodes, it is necessary to use reversible—electrodes like $\text{Ag} \rightleftharpoons \text{AgCl}$, $\text{Zn} \rightleftharpoons \text{Zn SO}_4$

In the above experiment, it is the liquid which moves. By analogy with the phenomenon of Osmosis, the movement of the liquid is called electro—Osmosis. By a modification of the apparatus the movement of colloidal particles can also be shown

This movement of colloidal particles in an electric field is known as electrophoresis or cataphoresis. The rate at which the colloidal particles move depends on their charge, size and shape. It is of the order of 10^{-4} cm per second for a potential gradient of 1 volt per cm. The direction of movement can be used to ascertain whether the colloidal particles are positively or negatively charged.

Colloids are generally classified into two main class Lyophillic and Lyophobic i.e. solvent attracting and solvent hating. The former are thermodynamically more stable than the latter.

An interesting property of the colloids is the scattering of light by them. Since scattering depends upon a difference in refractive index of the particle and the medium, it will be large with the hyobolic colloids and

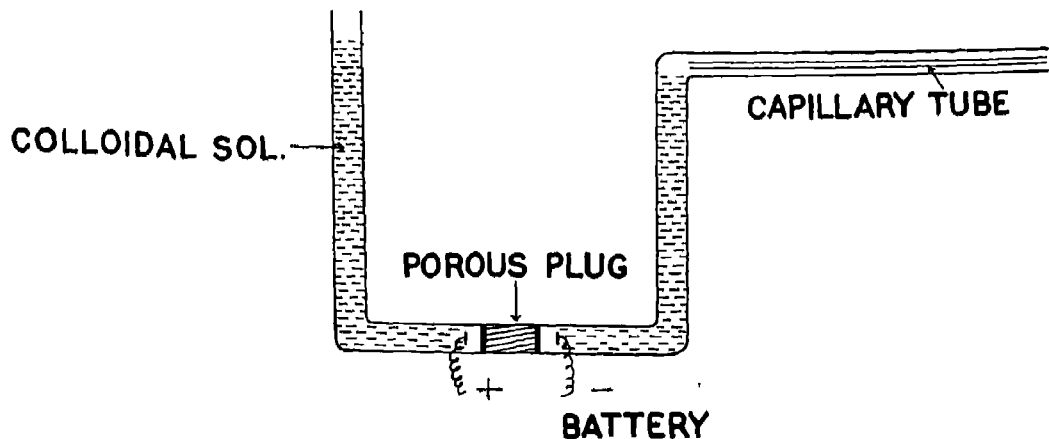


Fig. 1. Movement of liquid under applied potential

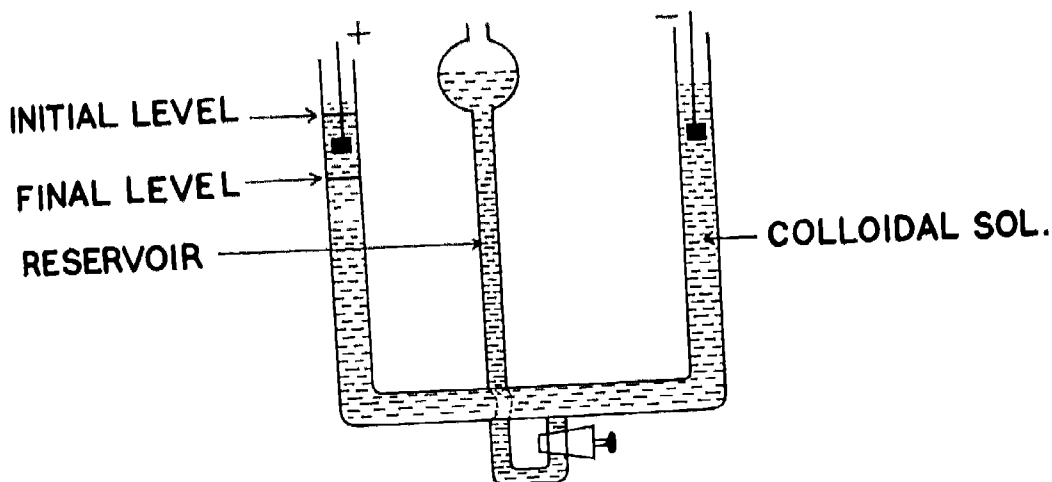


Fig. 2. Movement of colloidal particles under applied potential

small with hydrophillic ones as in the latter case, the particles are so strongly solvated and often probably penetrated by solvent molecules that there is very little difference in refractive index of the colloidal particles and the solvent.

For a dilute suspension of spherical particles of radii less than $1/20$ th of the wavelength of incident light, Lord Raleigh obtained the following formula for scattering:

$$\frac{I_s}{I_i} = \frac{8 \pi^4 \alpha^2}{\lambda^4 r^2} (1 + \cos^2 \theta)$$

where I_s = the intensity of scattered light
 I_i = the intensity of incident light
 α = the polarizability of the particle
 r = the radius of the particle
 λ = the wave-length of incident light
 θ = the angle at which light is scattered

One point is quite clear from the above equation. There is a strong inverse dependence on the wavelength of light. The shorter the wave length, the greater the scattering. This explains why the sky is blue. The blue light is scattered to a greater

extent by the tiny dust particles suspended in the atmosphere.

Classical chemistry treats molecules as rigid little spheres. When molecules become bigger, they may become either giant spheres or plates or threads. This dissymmetry shows itself in making the viscosities of solutions, unusually high.

The overall nature of colloids can be discussed under the following heads:

- (i) Surface properties.
- (ii) Electrical properties.
- (iii) Optical properties.
- (iv) Kinetic properties.

Opportunities to apply the fundamentals of colloid and surface chemistry in Industrial Research are many and varied. One reason for such a strong interest in surface chemistry is that it is difficult to avoid interfaces. Most of our operations are contained by surfaces, many of them involve the creation and destruction of interface and quite a number of them occur at interfaces. Some of the fields in which study of surfaces plays an important role are:

- (1) Nucleation and growth of crystals.

- (ii) Nucleation and growth of bubbles.
- (iii) Strength of materials on grinding.
- (iv) Sintering of ceramics and other materials.
- (v) Catalysis by fine powders.
- (vi) Surface coatings and adhesives.
- (vii) Lubrication and prevention of wear and tear.
- (viii) Corrosion and its inhibition.
- (ix) Soils, their swelling and exchange capacity.
- (x) Stabilization of emulsions, foams and gels.
- (xi) Evaporation control.
- (xii) Flotation of minerals.

Plant Lore of Rajghat

G.S. PALIWAL and MISS LATITA KAKKAR

Department of Botany,
University of Delhi,
Delhi 7.

RAJGHAT the samadhi of Mahatma Gandhi—has acquired unique significance amongst the revered memorials in the history of the Nation. On the eve of the Birth Centenary of Mahatma Gandhi this year, we thought of surveying Rajghat and paying our respects as botanists by exploring the variety of plants that adore the cherished memory of this great saviour of mankind.

The Location

Rajghat is situated on the banks of the river Yamuna, on Ring Road, covering an area of about 18 ha. The Samadhi is surrounded on the south and east by the Power House, on the west by Ring Road, and on the north by SHANTI VANA, the Samadhi of Shri Jawahar Lal Nehru.

The plants have been gathered from different parts of the country as well as from different countries of the world. Whether you are looking at the *Pinus* planted by Queen Elizabeth, or the *Magnolia* tree commemorating the visit of the late President Eisenhower, a sapling of *Cassia* by President Nixon, or even the latest addition of banyan tree by Khan Abdul Gaffar Khan, the theme always

remains the same: Mahatma Gandhi's message of Ahimsa is for ever and the moral values he introduced into politics will be upheld as true for many generations to come.

The general layout of the Samadhi has been planned in a very simple but impressive manner. The site is broadly divisible into a lower small rectangular piece of land in the front followed by a raised platform on all sides, covering a much larger area. The main Samadhi is located in the centre surrounded on all sides by stately built, cave-like arches of shining white stone. Four majestic silver-oak (*Grevillea robusta*) trees decorate the corners of the enclosed square. These are accompanied by trees of "Ashok" (*Polyalthia longifolia*), *Juniperus*, and Champa (*Plumeria rubra* forma *acutifolia*). Neatly trimmed grass patches are maintained, interspersed in between the stone slabs and the winding paths leading from the entrances to the main platform of the Samadhi, made up of black marble and bearing the last words 'He Ram' uttered by the Father of the Nation.

The stairs from the entrances to the gates are bounded by hedges of *Lantana* (bearing violet flowers) and *Hypericum*. The main attraction in the *Hypericum* these days is provided through its lush green leaves which impart an extremely soothing sensation to the tired eyes. It is mainly because of this effect that it has been planted so heavily at the edges of the raised platform, towards the lower rectangle. Intermixed occur medium-sized shrubs of *Bougainvillea spectabilis* bearing flowers of different shades.

From the point of view of the ornamental plants, the main centres of attraction are the nicely arranged beds alround. Among the important plants which can be seen in flowering these days are the variously coloured Kellees (*Canna indica*) Sunflower or Surajumukhi (*Helianthus annuus*) *Hypericum* sp., *Jatropha panduræfolia*, *Lantana camara*,

Mussaenda luteola, *Plumbago capensis* and *Vinca rosea*. The medium-sized trees of *Lagerstroemia speciosa* and *Cassia siamea*, the shrubberies of *Hamelia patens*, *Hibiscus rosa-sinensis*, *Lagerstroemia indica*, *Tabernaemontana divaricata*, and climbers such as *Gmelina philippinensis*, *Pyrostegia venusta* and Juhí (*Jasminum auriculatum*) are also in full bloom adding a magnificent charm to the environment.

Flowers Round the Year

Earlier, in the summer months, in the blazing sun of Delhi, the plants that reach their climax of flowering are, Gulmohur (*Delonix regia*) Barbados' pride (*Poinciana pulcherrima*), violet-flowered *Jacaranda mimosifolia* and crimson-red Amaltas (*Cassia fistula*). Such other shrubs which can be seen to flower from mid-summer to the beginning of the rainy season are *Bougainvillea spectabilis*, *Tecomaria capensis* and *Buddleja asiatica*. Among the fruit trees mention may be made of Mango or Am (*Mangifera indica*), Peach or Aru (*Prunus persica*), and Pomegranate or Anar (*Punica granatum*). Several majestically standing tall trees of *Eucalyptus globulus*, and *Ficus religiosa*, *Mimusops elengi*, *Alpinia speciosa* and *Magnolia grandiflora* impart an attractive look to the scenery around the southern road.

Kachnar (*Bauhinia purpurea* var. *variegata*), a medium-sized tree with rose-coloured flowers reaches its zenith of flowering in winter and adds much charm to the Samadhi. This season also displays matchless flowers on the 'tree of sorrow' or Harsingar (*Nyctanthus arboristis*). Its creamy white flowers with orange shade on their corollas, open late in the evening, scent the night air with fragrance, and drop off early next morning. The other plants flowering during winter months include *Acacia auriculiformis*, *Dombeya cayeuxii*, *D. natalensis*, *Eranthemum*

nervosus, and *Jasminum multiflorum*.

Spring brings along with it a peerless majesty of vegetation to the Samadhi. Now flowers one of the loveliest trees, the Mountain Ebony or Kachhnar (*Bauhinia variegata*) a few trees of which have been planted at the lower edges of the raised platform. The trees of shield bear (*Peltophorum pterocarpum*), Small coral (*Erythrina variegata*) also bear flowers during this season. The greenish scented inflorescences of *Mangifera indica* drooping, bottle-brush-like inflorescences of *Callistemon lanceolatus* and Kusum (*Schleichera oleosa*) with its conspicuously red foliage also impart their share to the magnificence of Rajghat in spring. Madhavilata (*Hiptage benghalensis*) bearing white and yellow or light-mauve flowers and *Sophora secundifolia* with violet-blue flowers further add to the excellence of the shrubbery.

Outside the Samadhi, on the roads are planted avenues of *Eucalyptus globulus* with their mild, warming, spicy odour, Chandelion trees (*Rigella pinnata*) and the dark green *Pongamia pinnata* posing a very attractive look. A few trees of *Alstonia scholaris*, *Terminalia arjuna* also decor the roads along with a row of *Ficus lacor* planted at the Bela Road near the front gate. The hedge around the garden mostly comprises *Lagerstroemia indica*, *Haematoxylon campechianum*, *Prosopis juliflora* and *Tabernaemontana divaricata*. A few trees of *Merus alba* also occur dispersed especially near the water coolers. In the fallow land, between the Power House and the Rajghat one still finds a thick coverage of the Shisham (*Dalbergia sissoo*) trees.

Although quite satisfactory, the layout and the upkeep of Rajghat leaves much to be desired. The foremost lapse on the part of the management is the absence of name plates (but for a few wrongly named plants), on the trees, shrubs and in the plots of the ornamentals. The general public, and espe-

cially the foreign visitors are always kept guessing about the nomenclature of the vegetation. Selection of *Haematoxylon* as a hedge plant is poor. Its thick, uncovered trunks at the basal regions gradually become sparse and unseemly. Many more scent emitting plants such as *Gardenia jasminoides*, *Cestrum nocturnum* and *Michelia champaka*

should find a place. A selection of climbing roses, jasmines, ipomoeas, antigonons and *Quisqualis indica* coupled with a blend of *Petrea volubilis*, *Thunbergia erecta* and *Duranta repens* (which flowers around most part of the year and is an excellent hedge plant) are bound to add a definite charm to the layout of the place.

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Classroom experiments

Plant Physiology Kit

A.C. SAIGAL,
State Institute of Science Education,
Allahabad.

PLANTS, like animals are living and dynamic entities. It performs all those vital activities which take place in an animal's body. It feeds, digests, respire, excretes, responds, reproduces and grows. In some way, it is more than that. No scientist in the world has so far been able to manufacture food in a test tube out of such inert raw materials as carbon dioxide and water. The plant is able to synthesize carbohydrates, proteins, fats and a host of other things in its body with the help of chlorophyll, carbon dioxide and water. A Higher Secondary School student cannot visualize that a plant performs such important vital activities unless he does experiments with his own hands. Of late, it has been advocated that the teaching of biology should be based on 'Enquiry into Life' principle. The present practice in our country is to give, at the most, a demonstration of plant physiology experiments to the students in the class. This practice is followed even in B.Sc. course. To my mind, it is so because the conventional apparatuses are costly and their setting up is a bit technical and time

consuming. They are fragile too and are liable to break in the hands of unskilled hands. Considering these difficulties the present kit on plant physiology has been devised from the point of view of Higher Secondary School students. With such a kit in their hands and given proper instructions by the teacher, students can themselves investigate the activities of plants.

Special Features of the Kit

1. Simple glass and plastic items like thistle funnel, U-tube, glass tubing, rubber corks, plastic cups, wire clamps and wooden stands have been used.
2. Conventional experiments have been modified to suit the pieces of apparatus selected.
3. Manipulation is easy and apparatuses handy.
4. Mercury, being too costly these days, has been replaced by other fluids. Alternative experiments, avoiding the use of mercury and other costly chemicals, have been suggested.
5. All the experiments given in the text have been tried in the laboratory and found successful.
6. Details for doing the experiments have been laid down in the text.
7. The box serves for storing apparatuses and for using it as a *phototropic chamber*. The cost of the Kit, including the container comes to about Rs. 15.00.

The Kit—It consists of the following items:

- I. Box made of wood—dimensions—
35×18×15 cm.

II. Glassware

Items	Number
1. U-tube—height 13.5 cm.	2
2. Thistle funnel—Diam. 3 cm. Stem. 2 cm.	3
3. Glass tubing bent at right angles	2-3
4. Glass tubing—length—18 cm bore—narrow	1
5. (a) Test tube hard glass—Diam. $2\frac{1}{2}$ cm.	1
(b) Test tube ordinary—Diam. $1\frac{1}{2}$ cm.	2
6. Beaker 100 ml.	1
7. Glass tubing open at both ends— Diam. 1 cm. Length 8 cm.	1
8. Specimen tubes with corks Length 6 cm. Diam. 1 cm.	4
9. (a) Glass plates—size: length 23 cm.	2
(b) Watch glasses—breadth—12 cm	2
10. Spirit lamp	1

III. Other Materials

11. Blocks of Wood—7 cm. cubes—	2
12. Thick galvanised 30 cm. long iron wire and ring with clip	
13. Hollow bamboo piece— Length 6 cm. Diam. $1\frac{1}{2}$ cm.	
14. (a) Rubber corks with one hole—2	
(b) Rubber corks with 2 holes	2
15. Dry egg membrane	1
16. Cellophane covers—red, blue and colourless: size 14 cm \times 12 cm	1 each
17. Polythene bag—size—13 cm \times 8 cm	1
18. Small plastic case—diam. 3 cm. to keep, egg membrane, cover slips etc.	1
19. Forceps	1pr
20. Paper clip	2
21. Rubber droppers	2
22. Bamboo test tube stand	1
23. Rubber sleeves	4

IV. Chemicals

Chemicals (Solutions to be prepared in bulk by the teacher and provided to students).

Spirit, iodine solution, sodium hydroxide, manganese sulphate, sodium bicarbonate, lime water, yeast tablets or toddy, glucose, potassium hydroxide, pyrogallol, candle, chloroform calcium hypochlorite 5% etc.

Enquiry 1—Transpiration in Plants

Materials:

Polythene bag—15 cm. \times 10 cm.

U tube—1

Rubber corks

(No. 2) with one hole each—2

Glass tubing bends — 2

glass tubing 18 cm. long with narrow

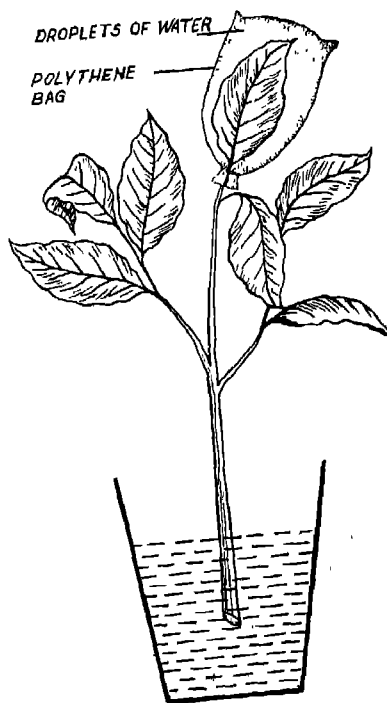


Fig. 1 Leaves give out water vapour (Transpiration)

bore (about 3 mm. and 5 mm) 2
 Rubber sleeves — 2
 Plastic cup — 1
 Small twig with tough and leathery leaves
 Chloroform
 Stand
 Beaker — 100 cc. — 1
 Watch glass — 1

Experiment-1 Demonstration of Transpiration

Remove a twig from a plant having *tough* and *leathery* leaves and dip its end in water. Tie a polythene bag tightly round the apex so as to enclose a few leaves within it (Fig. 1). Examine after 1/2 hour. What do you notice inside the bag? Let the bag remain round the twig overnight. Collect the transpired water and measure it. Can you guess how much water a whole tree might transpire in a day?

Experiment-2 Transpiration Rate in Leaves: To set up a simple potometer

Cut a twig having at least 2 dozen *tough* and *leathery* leaves half an hour before the experiment and dip the stem end in water. To each end of the 18 cm. glass tubing attach one bent glass tube by means of a rubber sleeve or joint. Insert the left hand bent tube in the bore of a rubber cork. Fix up the twig tightly to the other cork and set up the apparatus as shown in the figure (fig. 2). It is advisable to do the setting under water so that air does not put a hindrance in making the apparatus air-tight. If water stays in the tubing after the apparatus has been taken out of water, it is air-tight. If it leaks, the experiment has to be set again. Fix up the apparatus to a stand. Squeeze the rubber sleeve nearest the cork so that a drop of water comes out at the free end. Now slowly release the rubber sleeve till a bubble about 1 cm. in length enters the free end. Immediately dip the end in a plastic cup containing water.

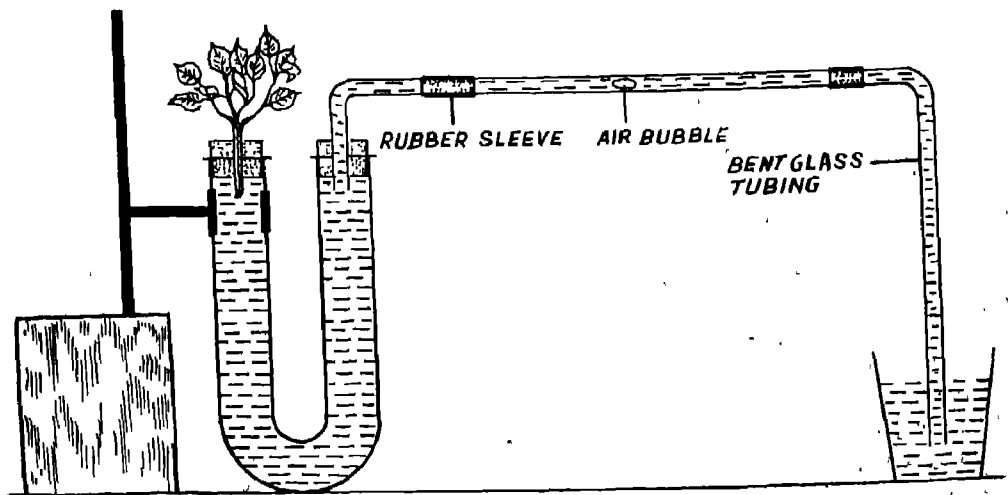


Fig. 2 Potometer measures transpiration rate

After about 15 minutes observe the position of the bubble. Has it moved ahead? After it has reached the horizontal tube, mark its position and note how much time it takes to move 3 cm. Now put the fan on and note the time the bubble takes to move another 3 cm. Does air speed up transpiration? By taking the twig of another plant, you can compare the rate of transpiration in the two plants.

Experiment-3. Transpiration produces suction

Fix a tightly fitting rubber tubing about 2.5 cm in length to one end of the narrow bore glass tubing. Cut out a twig under water from a plant having leathery leaves half an hour before starting the experiment. Dip it in water to keep fresh. Fill water into the glass tubing from the end to which rubber

tube is attached. Press your finger at the other end and with the help of your class mate fit the twig tightly to the rubber tubing. See that the entire arrangement is air-tight.

Fill *chloroform* to about $\frac{1}{3}$ height in a 100 ml. *glass beaker* (not plastic cup) and colour it with 4-5 drops of iodine. Chloroform will be coloured beautiful crimson. Add water to the beaker so that it is about $\frac{2}{3}$ full. Now dip the free end of the glass tube to which the twig is attached into chloroform and remove your finger when it touches the chloroform level. Fix the apparatus to a stand as shown in the diagram (Fig. 3).

After about 20-25 minutes you will observe chloroform rising in the glass tubing. What causes suction of chloroform? How will the rate of rise be affected if the apparatus is placed under a fan and in humid atmosphere? What factors control transpiration?

You will now realise that transpiration from leaves serves as an upper motor mechanism for sucking up water in the xylem vessels and maintaining a continuous stream of water from the root to the top.

NOTE: This experiment is usually done with mercury. Mercury is a costly metal and every institution cannot afford to purchase it. Chloroform is heavier than water and is immiscible with it. It is a good substitute and admirably suitable for this experiment. The results are quicker than in mercury. Carbon tetrachloride can also be used in this experiment.

Enquiry-2. Respiration in Plant Organs (Leaves, Petals, Buds, Tissues etc.)

Material

Rubber cork No. 6 (diam 3 cm.) 1
with 2 holes

Rubber cork No. 6 (diam 3 cm.) with 2
holes—1

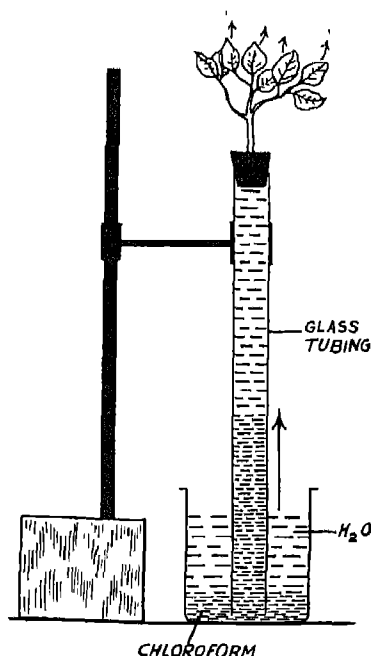


Fig 3 Transpiration produces suction.

Thistle funnel with 2 cm. stem--1
 Glass tubing, 12 cm. long--1
 Bent glass tubing--2
 Fresh twig with leathery leaves
 Lime water
 Specimen tube
 Plastic basket or a small wire gauze piece
 Soaked seeds, glucose solution
 Yeast tablets--4 or toddy

Experiment-1: Air Enters Through Stomata

SLIP over a tube bent at right angles to the short stem of a thistle funnel by means of a rubber sleeve. Pack bits of cotton between the cork and the petiole and apply a little melted wax, if necessary, to make it

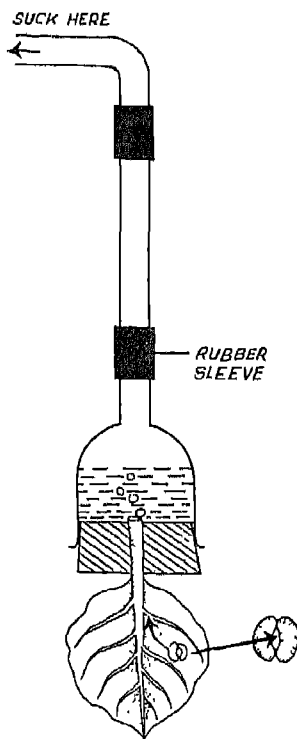


Fig. 4 Air enters through stomata

fully air-tight. A leaf having *fistular petiole* or one with *loosely packed tissues* (Cucurbitaceae family), castor or *colocasia* is preferable. Take some water in the thistle funnel and fit in the cork in the cup (Fig. 4). Now suck hard from the open end. Do you observe small bubbles of air coming out through the cut end of the petiole? Whence has the air come? Apply vaseline first on the upper surface and then on the lower surface of the leaf. Do bubbles come out of the petiole when you smear both the surfaces? Why?

Experiment-2 To Demonstrate that Plant Organs Respire.

Take a no. 6 rubber cork (diam. 3 cm.) having 2 holes. Insert the short stem of a plastic or glass thistle funnel into one of the holes from above and a glass tubing about 12 cm. long from below. To the other hole

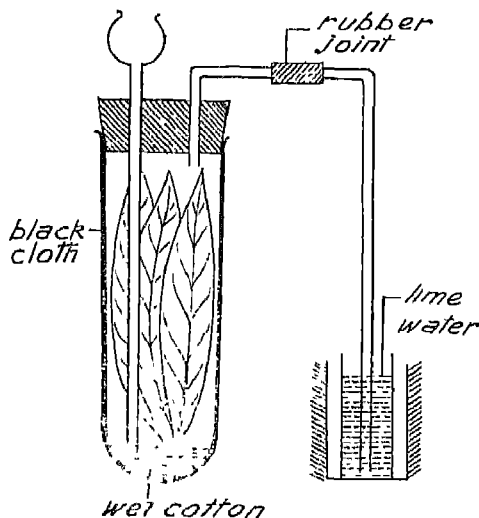


Fig. 5 Leaves take in oxygen and give out carbon dioxide.

fix up a glass tube bent at right angles. With the help of a rubber joint connect it to another tube bent at right angles but having one arm

much longer than the other as shown in the diagram (Fig. 5).

Place $1\frac{1}{2}$ dozen leaves having a *linear structure and leathery texture* into a boiling tube. Put in a small piece of wet cotton or a little water at the bottom of the tube to keep the leaves fresh. Fit in the 2-hole cork to the tube. Dip the free end of the delivery tube in a small specimen tube containing a little lime water. Place the apparatus in dark or slip over a black cloth over the tube. Let it remain undisturbed for an hour. Now pour water into the thistle funnel. You will notice bubbling in the specimen tube. Observe the colour of the lime water. It has turned milky. Why? What result do you expect if the apparatus is not covered with a black cloth? Why does a nurse remove flower pots in the night from the room of a patient? Why do fishes surround vegetation in shallow water in the day time? Use this very apparatus for demonstrating respiration in germinating seeds, coloured flower buds, petals, tissues of potato, apple etc. The apparatus need not be kept in the dark, Why?

Experiment-3: Anaerobic Respiration in Germinating Seeds.

Usually this experiment is done with mercury which being too costly these days is usually not available in all the Higher Secondary School laboratories. An alternative experiment has been devised and it works very well.

Use the same apparatus as in the above experiment. Take about 10 ml. of *concentrated alkaline pyrogallol* in the boiling tube and lower a wire basket containing 10 soaked pea seeds into the tube quarter way down and close the tube with a rubber cork to which thistle funnel and delivery tube is attached (Fig. 6). Dip the lower end of the delivery tube in a specimen tube containing

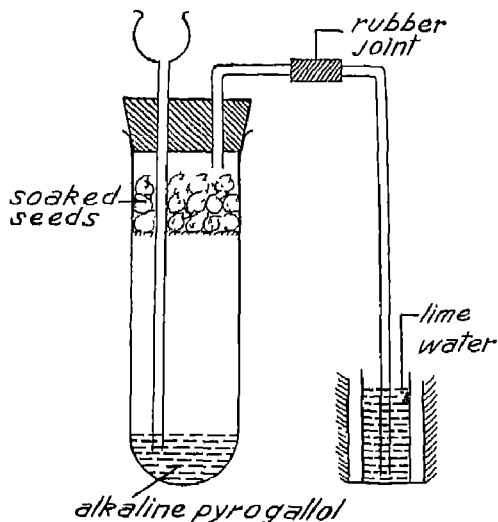


Fig. 6 Seeds respire anaerobically

milky water. Next day pour water gradually into the thistle funnel. The displaced gas will bubble through lime water and turn it milky. *Alkaline pyrogallol* absorbs oxygen inside the closed space of the tube and respiration in seeds proceeds on anaerobically. To obtain quicker results dip the end of the delivery tube in 1% potassium hydroxide solution. Examine after 2 hours. You will find that potassium hydroxide rises in the tube to about 2 cm. or so.

Place the apparatus at a safe place and examine after a week. Have the seeds germinated? This experiment also proves that oxygen is essential for germination.

Experiment-4. To Demonstrate Fermentation

Take about 10 ml. of 50% glucose solution and mix with it 10 ml. of concentrated toddy (Tari) or 2-4 yeast tablets. Pour the above mixture into the boiling tube and fit up the apparatus as above. After one hour pour water into the thistle funnel and observe

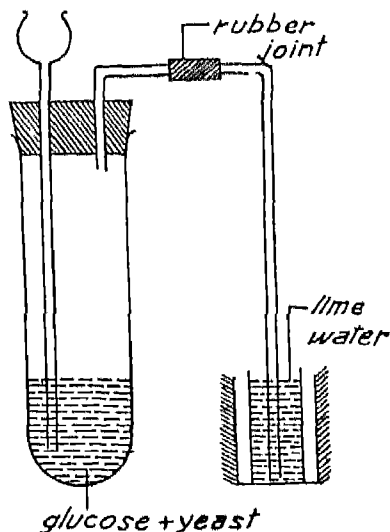
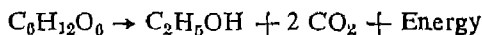


Fig. 7 Yeast causes fermentation in glucose solution

the colour of the lime water in the specimen tube (Fig. 7). It turns milky. What causes the evolution of carbon dioxide from glucose? The following equation explains the reaction.



Open the cork next day and smell. Do you feel the smell of ethyl alcohol?

Enquiry-3

Materials

Boiling tube-1

Test tube-1

Watch glass-1

Plastic cups-3, Specimen tubes-3,

Cellophane Covers—

Red, Blue, and White

Tumblers-2, glass plate-2.

Droppers-2.

Sodium bicarbonate, Spirit, Iodine Solution, Fresh potato or brinjal leaves.

Manganese sulphate, Sodium hydroxide, Chalk stick, *Hydrilla* twigs.

Fill 1/3 of boiling tube with water and place within it a test tube containing about 15 ml. of rectified spirit. Dip a small potato or brinjal leaf plucked *at least 4 hours after sunrise* into the spirit. Fit the boiling tube to a stand and boil the water (Fig. 8). In about 30 minutes, the leaf will

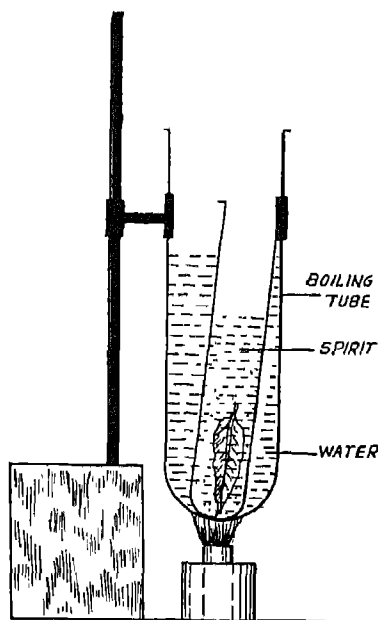


Fig. 8 Leaves manufacture starch

be completely decolorised. Take out the leaf and dip in boiling water to soften it. Now wash it well and spread over a watch glass. Put in 3—4 drops of Iodine Solution and watch the result. Does the leaf turn blue? Why? It shows the presence of starch in the leaves.

Repeat the experiment with a plant which has been destarched by keeping it in dark for 24 hours. Does it give the starch

test with iodine? It conclusively proves that starch is manufactured in green leaves in the presence of light.

Experiment-2: Carbon Dioxide is Essential for Starch Formation

Destarch the leaves of a plant by keeping it in dark for 2 days. Pluck 2 leaves and dip the petioles in a small beaker containing water. Place the beaker on a glass plate. Light a candle and cover the beaker and

fill a plastic cup with tap water and dissolve 2 gm. of sodium bicarbonate into it. Fill up the cup to the brim. Insert the cut ends of the *Hydrilla* twins into the stem of the thistle funnel and place it mouth downwards into the cup. See that the twins are completely enclosed in the cup of the thistle funnel. Insert a rubber cork into the upper end of tube. Fill it with tap water and putting your finger tip at the open end, insert it on to the stem of the thistle funnel (Fig. 10) Place

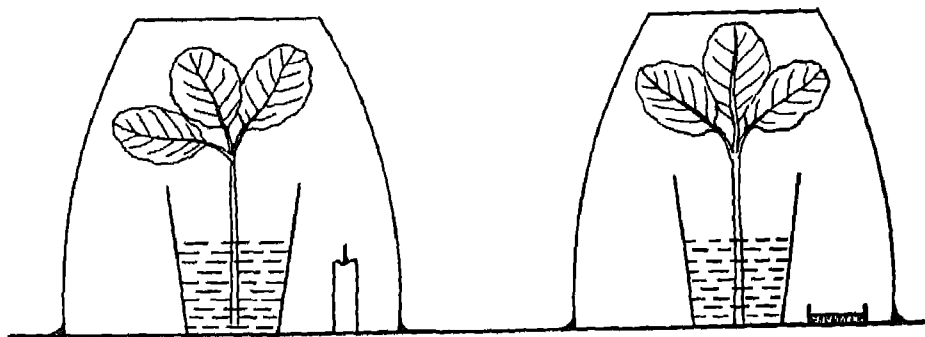


Fig. 9 Carbon dioxide is essential for starch formation

the candle with a large tumbler (Fig. 9). The candle will be extinguished and the air inside will be charged with carbon dioxide. Apply vasaline round the rim of the tumbler.

Set up a control experiment side by side. Do not light a candle here but place a little *potassium hydroxide solution* so that the air inside is deprived of carbon dioxide. Let the apparatus remain in diffused light for 2 hours. Decolorize the leaves and test for starch. You will find that the leaves in the control experiment are not stained blue with iodine whereas in the other case they get stained.

Experiment-3: Oxygen is given out during Photosynthesis

Select 2 fresh twins of *Hydrilla* plant and cut out 6 cm. pieces from the top. Half

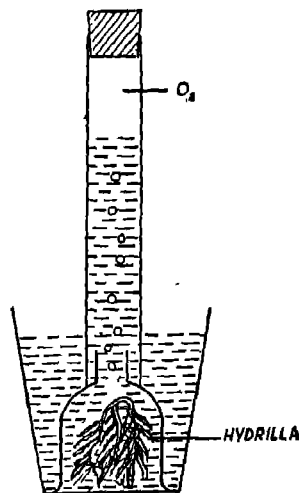


Fig. 10 Oxygen is given out during photosynthesis.

the apparatus in bright sunlight. You will notice small bubbles coming out of the plant and collecting in the tube. Let the apparatus remain in bright sunlight for 2 hours. By this time the tube may be half filled with gas. Open the cork and introduce a thin burning straw into the tube. The straw begins to glow brightly. What gas is it?

Experiment-4: Oxygen is given out during photosynthesis (Chemical Method)

It is a chemical method of proving that oxygen is given out during photosynthesis. In this experiment results are obtained within half an hour.

Fill 3 specimen tubes with tap water. Cut 4 twigs of *Hydrilla* plant from the tip and place 1 each in two of the tubes. Don't place twig in the 3rd tube. Put the 1st tube in sun, the 2nd in dark and the 3rd anywhere in the lab. (Fig. 11). After half an

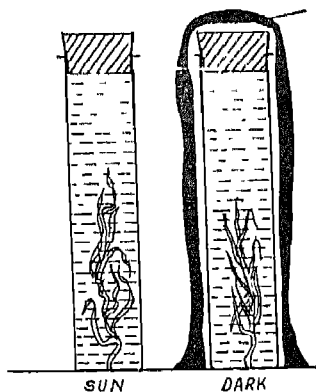
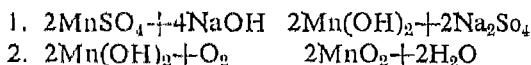


Fig. 11 Oxygen is given out during photosynthesis (chemical method).

hour remove the twigs from the tubes and pour in 3 drops of concentrated solution of manganese sulphate and sodium hydroxide turn by turn in each of the three tubes. Use separate droppers for each of the solution. You will notice:

1. A brown precipitate in the tube placed in sun.
2. A white precipitate in the tube placed in dark
3. A very light brownish colour in the tube without plant.

The following equation represents the chemical reaction taking place



In the 2nd and 3rd tube manganese hydroxide is formed which has got a flesh colour. When manganese hydroxide reacts with oxygen liberated as a result of photosynthesis, manganese dioxide is formed and the precipitate gets darker brown.

Experiment-5: Maximum Photosynthesis takes places in blue and red light.

From fresh *Hydrilla* plants, cut a dozen 6 cm. twigs from the top and select out 8 pieces having approximately the same number of leaves. Take 500 ml. of tap water in a breaker and dissolve 10 gm. of sodium bicarbonate in it. Fill up 3 plastic cups to the brim with the solution. Insert 2 twigs into the stem of each of the four funnels and set up three such apparatuses as in the previous enquiry. Cover them with red, blue and white cellophane covers and place them in bright sunlight (Fig. 12). Let the apparatuses remain in sunlight for 2 hours. Measure the height of the tube to which oxygen has collected in each of the tubes. You will notice that maximum quantity of oxygen has collected in red light and second maximum is in blue light.

Experiment-6: To separate different pigments in Chlorophyll by simple Chromatography

Chromatography means "colour writing"

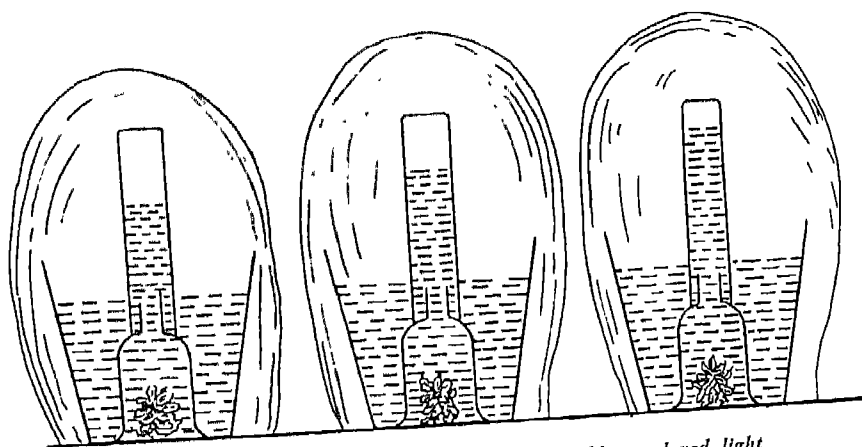


Fig. 12 Maximum photosynthesis takes place in blue and red light

By this technique the components of chlorophyll i.e. chlorophyll a and b, carotins and xanthophyll can be separated.

You have already extracted chlorophyll in experiment no. 1. Pour it in a watch glass and let it remain as such for a few minutes so that a part of the solvent gets evaporated and the extract becomes concentrated. Stand

a piece of chalk in the centre of the watch glass (Fig. 13). Examine the chalk piece after 15 minutes. You may see 3-4 bands—two green bands representing chlorophyll a and b; yellow band—representing carotin and, if you are able to get a brownish band, it is xanthophyll. In this experiment these substances in solution are separated by an adsorption process and by capillary action. Different components of chlorophyll move up at different rates and hence you see the characteristic bands at different heights on the chalk piece.

Use *mint*, *lettuce* or *brinjal* leaves in this experiment

Enquiry-4: Osmosis

Material

U tube; Thistle funnel, Bent tubes; Rubber cork-Rubber sleeves-2, 10% Sugar solution, Dried egg membrane, Potato disc, Onion bulb membrane or potato disc

Experiment—1: To Demonstrate Osmosis

The experiment on osmosis can be set up with U tube.

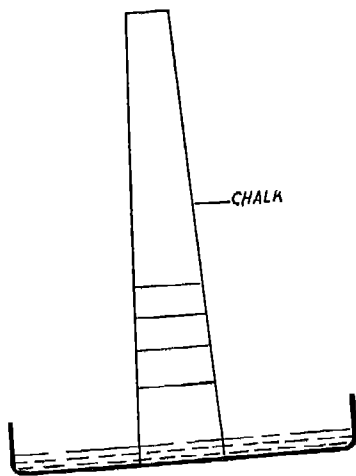


Fig 13 Separation of chlorophyll pigments by simple Chromatography

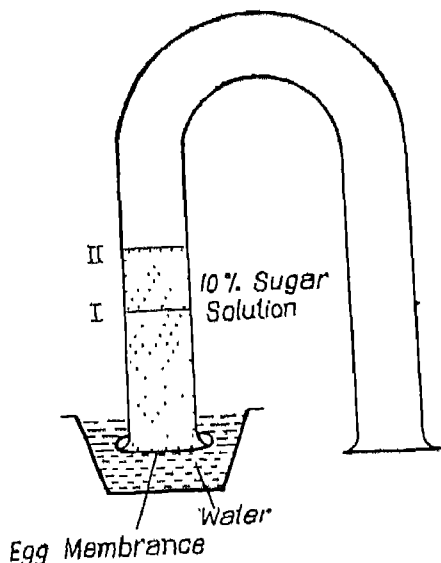


Fig. 14 *Demonstration of Osmosis by egg membrane*

Soak a dried egg membrane in water for 1/2 hour and tie it securely to one of the open ends of the U tube. Fill in about 10cc. of 10% sugar solution from the other end and tilt it a little so that the solution comes to occupy the membrane side. Dip

the membrane end in tap water contained in a plastic cup. (Fig. 14) Clamp the U tube to a stand. Mark the level of sugar solution in the arm of the U tube. Observe after 2 hours. You will notice a rise of about 3-4 mm. Why does the level rise up? The egg membrane serves as a semipermeable membrane. The concentration of water molecules outside the membrane is higher (100%) than the concentration of water molecules inside (90%). Since diffusion of molecules takes place from a region of higher concentration to a region of lower concentration, therefore water from outside diffuses towards the sugar solution through the semipermeable egg membrane. This process is known as osmosis. Leave the apparatus overnight and observe the level of water next day. You will find appreciable rise.

The principle of osmosis should be very clearly understood at the high school stage. All the nutritional processes in living beings—plants and animals—depend upon diffusion through a semipermeable membrane which has been aptly called "the Guardian of Life."

An alternative experiment can be per-

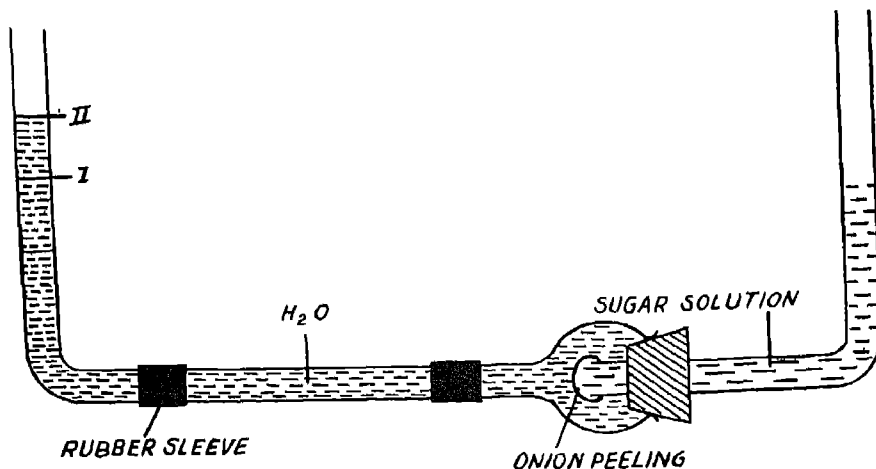


Fig. 15 *Demonstration of Osmosis with plant tissues.*

formed with a thistle funnel and a potato disc or onion membrane as indicated below.

Experiment-2. Demonstration of Osmosis with plant tissues

Set up the experiment as shown in the diagram (Fig. 15). Insert a rubber cork through one end of a tube bent at right angles. Let about 1 1/2 cm. of the tube end project beyond the cork. Cut out a potato disc, 1 cm. thick and having the same diameter. Bore a hole 3/4 cm. deep in the potato disc with a cork borer and fit it at the end of the test tube. Fill the tube with water and the funnel with 10% sugar solution. Fit the cork tightly in the thistle funnel. Mark the level of fluids in the bent tubes. Rest the apparatus against a support. Note the level after half an hour. You may notice a rise in the level of sugar solution. Why?

Instead of potato disc., membranous peelings from the fleshy leaves of onion can be tied to the tube end with thread

Enquiry-5: Germination Studies

Materials

Glass plates 25×12 cm—2

Blotting paper 25×12 cm—1

Soaked seeds of bean, maize and pea,

Enamel tray or a pad of cotton, stand,

Pyrogallic acid, sodium hydroxide, U tube, rubber corks.

Experiment-1: Comparative Study of Germination in Seeds

Soak 3-4 varieties of seeds overnight and then wash them thoroughly in 5% calcium hypochlorite solution. Have a glass plate 23×14 cm. and spread over it a thick piece of blotting paper of the same size. Wet the blotting paper and arrange seeds of pea, maize and bean as shown in the diagram (Fig. 16). The seeds may be placed in different positions. i.e., vertically, horizontally and

upside down. Cover the seeds with another glass plate of the same size and tie the 2 plates together at 2-3 places with rubber band or strong thread. Put the tied-up glass plates in a tray filled upto 1/3 with water or on a thick piece of wet cotton padding. This arrangement will allow the seeds to have a conti-

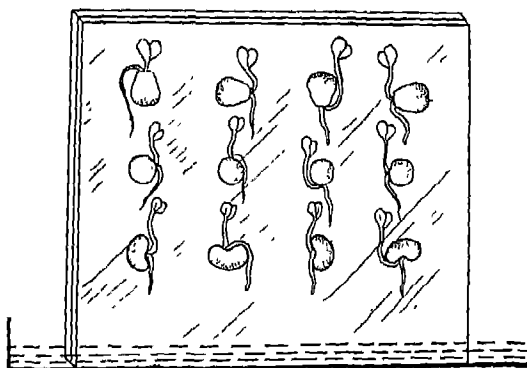


Fig. 16 Comparative study of germination in seeds.

nuous supply of water by capillary action. Put the apparatus in a corner and watch the stages of germination in different seeds at interval. Actual sketches may be drawn by the students. They may also note that in whatever position the seeds may be placed, the radicle always goes downwards and the plumule upwards, even if they have to take a turn of 180°.

Experiment-2: Oxygen is essential for the Germination of Seeds.

Place a little wet cotton on a rubber cork and insert it at one of the open ends of the U tube. Introduce about a dozen soaked seeds (which have been previously washed in 5% calcium hypochlorite solution) into the U tube from the other end. Take about 20 ml. of alkaline pyrogallol in a specimen tube or small beaker and dip the open end of the U tube in it (Fig. 17). In

about 2 hours time the pyrogallol solution will rise into the U tube and fill up $\frac{1}{5}$ of its length. Alkaline pyrogallol absorbs oxygen from the enclosed space. Set up a control experiment alongside.

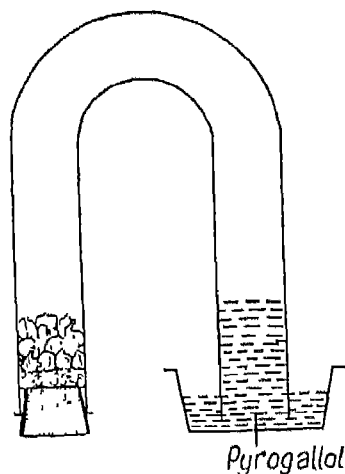


Fig. 17 Oxygen is essential for the germination of seeds.

Examine the apparatus after 3-4 days. Which of the two experiments show germination of seeds? Why do the seeds in the alkaline pyrogallol tube don't show the least sign of germination? What gas is essential for germination? Why do seeds fail to germinate if planted too deep in soil? Why does a farmer plough his fields and make the soil loose before sowing seeds? Will seeds germinate in hard and compact soil?

Experiment- 3: one-fifth of air is used up in breathing. Further growth of seedling stop when oxygen gets exhausted.

Set up the experiment as before. Place the free end of the U tube in potassium hydroxide solution instead of alkaline pyrogallol and place the apparatus at one side in the laboratory (Fig. 18) Observe after

3-4 days You will find that the seeds have germinated and have given forth radicles and plumules. Why has potassium hydroxide solution gone up the tube? What length of tube does it occupy? Observe the appara-

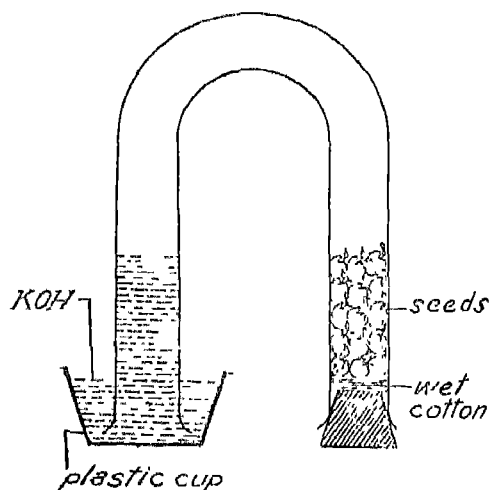


Fig. 18 One-fifth of air is used up in respiration by seeds

tus again after a week. Have the seedlings grown further? Why? This simple experiment shows that.

- 1 One-fifth of the air is used up in breathing by seeds.
2. Seeds need oxygen to germinate but as soon as oxygen gets exhausted further growth of seedlings stop.
3. Carbon dioxide is given out as a result of respiration. It is absorbed by potassium hydroxide and the level in the U tube rises to approximately $\frac{1}{5}$ of the total length of the U tube. In case pyrogallol is not available an alternative experiment can be done as follows:

Onto a glass plate place a wad of wet cotton and a 1 cm. piece of candle. Put 5 soaked wheat, barley or mustard seeds

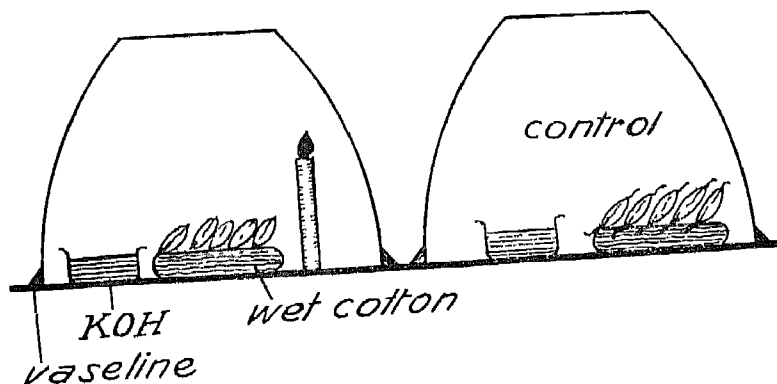


Fig. 19 Seeds germinate in the presence of Oxygen.

(quickly germinating seeds should be selected) on the wet cotton. Pour a little 1% potassium hydroxide solution in a small plastic container and place it alongside (Fig. 19)—Light the candle and cover it with a big size tumbler whose rim has been vaselined. Apply extra vaseline round the rim so that there is no possibility of the air getting inside. As soon as oxygen in the enclosed air is exhausted, the candle will be extinguished. Carbon dioxide given out by the burning candle will be absorbed by KOH. The seeds are thus surrounded by oxygen-free atmosphere.

Set up a control experiment along side in which the candle has not been lighted. Examine the seeds after 4-5 days. Which seeds show germination? The obvious conclusion is that oxygen is necessary for germination.

Enquiry-6: Plant Movements: Tropisms

Materials

Phototropic chamber (the box of the Kit). A few seedlings in plastic cup; Wick; Plastic cup; Stand.

Experiment-1: To demonstrate Phototropism

Plant 1/2 dozen seedlings of pea or gram

in a plastic cup and place it in the container of the kit which serves as a phototropic chamber. Close the lid and open the shutter fixed in front of the box. Observe after 3-4 days. If you allow the plants to remain in the box for a week, you will find that the growing stems come out of the aperture showing that *stems are positively photographic*.

Experiment-2: Geotropic Response

Set apart the two pieces of the hollow bamboo provided in the kit. Put a thick wick on one of the pieces and lay down a small pea, or bean seedling on the wick. Let one of the free ends of the wick dip in water as shown in the diagram (Fig. 20). Put the upper half of the bamboo piece in place and slip over a rubber band to hold the two pieces together. Fix the apparatus to a stand. After 3-4 days you will find that the root and the stem come out of the open ends of the bamboo and move in opposite directions. The stem being negatively geotropic goes up in the air and the root being positively geotropic goes down.

Conclusion—A resourceful student can devise many more experiments with the kit. By adding a few more items like slides, cover

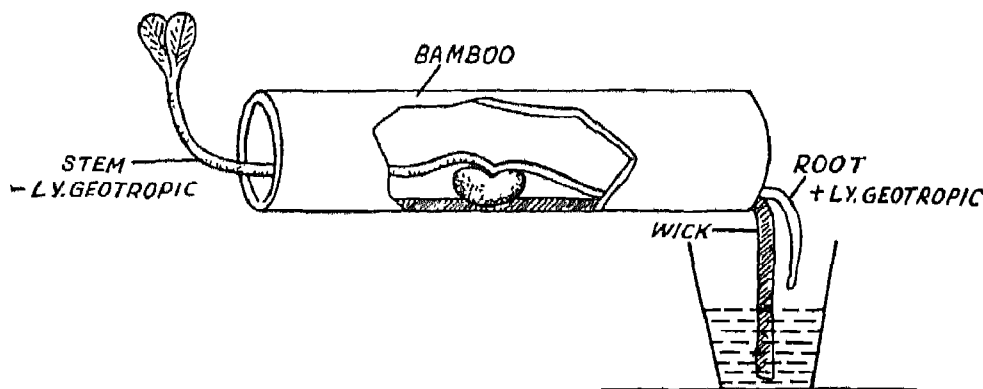


Fig 20 Roots are positively geotropic and stems are negatively geotropic.

slips, needles, injection phials, containing iodine, glycerine and safranin, it can be converted into a complete Biology Kit. In those labs. where the working tables are without cupboards, the students can keep their dissecting sets and other sundries in the box, lock it and pile up in a corner.

Introducing Structures of Substance in the First-stage course of Physics in Schools

A.A. TAMARIN, Unesco Expert
K.J. KHURANA,

Department of Science Education,
NCERT

An experiment to introduce, at an early stage, the elements of structure of substances was taken up with a view to explore the possibility of teaching Physics in the upper primary classes. Such an approach was aimed at imparting to the pupils modern undertakings of the basic properties of solids and fluids, pressure in fluids, and its transmission, some elements of the thermal phenomena, etc.

AN experimental science Project for improvement of Science Teaching was launched by the Department of Science

Education of the N.C.E.R.T. at the first instance during the school session 1965-66 in 12 schools of Delhi. On the basis of short study made, the project was extended to cover 30 schools in the next school session. The schools were provided with experimental text-materials, guidance materials, and the teachers were involved in inservice training. Difficulties of the teachers and the taught were studied and practical solutions were sought. Under this project, science is to be taught as separate disciplines and the teacher in mathematics is expected to teach physics, and another in biology and chemistry.

It was observed that the course developed earlier had scope for improvement. In the biology course some of the terms such as 'temperature' appeared at the very beginning and the pupils were not explained concepts of such terms either in the biology classes, or in the physics classes during the first year of the course. Moreover the experimental course in physics was more or less descriptive throughout the first year and did not emphasise on the understanding, of the various phenomena of physics included in the syllabus on the basis of modern concepts. In some

form or the other elements of the molecular structure of substances were dealt only towards the end of the first year and were not used for explaining the phenomena covered earlier. Whereas in the course of biology "structure of the cell" appeared at quite an early stage and this encouraged for bringing elements of the structure of substances at an early stage in the course of physics also.

Such a study of elementary molecular structure of substances has been introduced with a view to:

- i) impart a better understanding of physical phenomena included in the course of physics for the upper primary classes,
- ii) to provide basis for the logical development of the course,
- iii) pave the way for a sound understanding of the structure of substances and to help the pupils to form an idea about the matter, field and energy.
- iv) provide a background for the proper study of the course of physics, biology and chemistry during the First and Second stages.

On the strength of encouraging results, and in consonance with the recommendations of the Education Commission for introducing discipline approach in science, an attempt was made to develop learning materials for teaching physics to class V students in one of the experimental schools. The experiment was conducted during the school session 1968-69, both by the school teachers and the authors in two separate sections of class V. Before introducing the topics "*Structure of substances*" and "*some properties of solids and fluids*" the following topics were covered:

1. Introduction to physics,
2. measurement of length, area and volume,
3. force (including weight) and its measurement, thrust and pressure.

A summary of the scheme of the elements of the molecular structure of substances included in the first-stage of the physics course, spread over a period of three years of school education, is given below:

FIRST YEAR

1. Idea of molecule, its size and number in a drop of water. Concept of molecule (tiny ball as a first approximation).
2. Interaction of molecules and a general idea about their arrangement in substances. Mental model of interaction, forces of repulsion and attraction.
3. Spacing of molecules in solids and gases.
4. Temperature and molecular motion. Experiments confirming molecular motion. Idea about the connection between rapidity of molecular motion and temperature.
5. Thermal expansion and its simple explanation by the increased spacing between molecules due to more rapid motion.
6. Mutual mobility of molecules in substances. Molecular model of elasticity and plasticity. Fluidity of liquid. Compressibility of gases. Molecular model of gas pressure. Pascal's law as a result of mutual mobility of molecules in liquids and gases.
7. Molecules and the gravitational field. Explanation of the existence of atmosphere on the basis of escape velocity.

SECOND YEAR

1. Kinetic energy of a single molecule, Potential energy of molecules. Idea about internal thermal energy and its

connection with temperature of a substance.

2. Change of internal energy. Molecular model of thermal conduction. Molecular model of transfer of mechanical to thermal energy.
3. Idea about molecular structure of solids, liquids and gases
Crystalline and amorphous substances. Rearrangement of molecules because of melting and crystallisation of substances. Molecular model of evaporation. Action of molecular forces of attraction on molecules from a liquid.
Change in potential energy as a result of transition from one state to another (due to change in spacing between molecules)

THIRD YEAR

1. Structure of atom. Simple nuclear model and nature of forces between electron and nucleus. Free electrons in metals.
2. Structure of nucleus. Idea about proton and neutron. Elementary ideas about composition of nucleus, and nuclear reactions.

The school in which this experiment was tried is an experimental school. Because of the special environment, any school in Delhi may not be taken to represent the typical Indian school. Nevertheless, we may suppose that pupils are more or less the same all over the country, as far as their learning experiences are concerned. Both the sections of the class had co-education and their average age at the start of the school session was nearly 11 years.

The teaching method followed was that of teacher demonstrations involving frequent teacher-pupil participation leading to discussions resulting in logical conclusions. The conclusions were mainly drawn on the

basis of observations and the data collected by the pupils during the demonstrations. A bold attempt was made to bring in analogies and mental models wherever required to impart some information on a concept in simple popular way. Some interesting pupil activities, both in the form of short activities and pupil experiments were introduced with a view to provide the pupils with individual learning experiences. The evaluation was made mainly in the form of day-to-day oral questions supported by short written tests.

The learning materials distributed amongst the pupils were well-illustrated for the ideas covered. Presentation of the content was made in a popular language of physics, avoiding technical terms as far as possible. The aim was not to introduce the definitions of the technical terms, but to encourage the pupils to form a mental picture with the help of words and the illustrations. Although presentation of the materials was at the level of average pupils, additional information was provided in the form of well-planned illustrations, captions to illustrations, footnotes, thought provoking problems besides various suggested simple pupil activities catering to the needs of the above average students. The aim of distri-

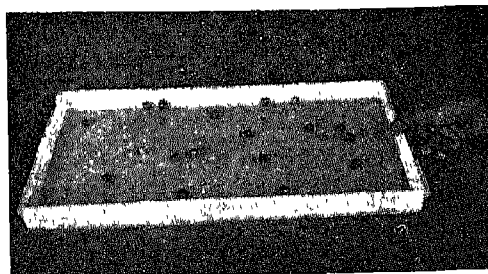
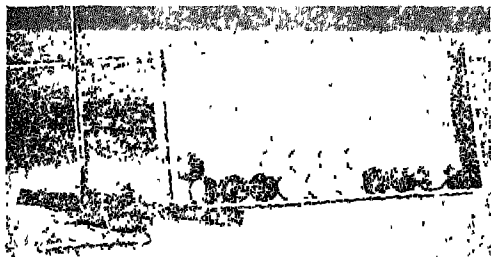
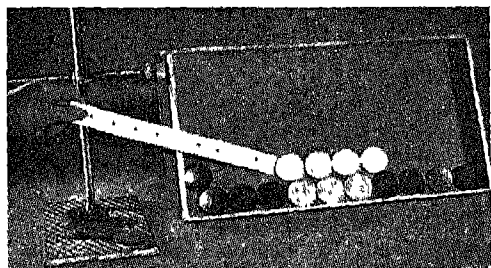


Figure 1. Study about structure of substances through simple experiments. Some marbles in a tray are used to give idea about the arrangement of 'particle' and intermolecular space in the different states of a substance.

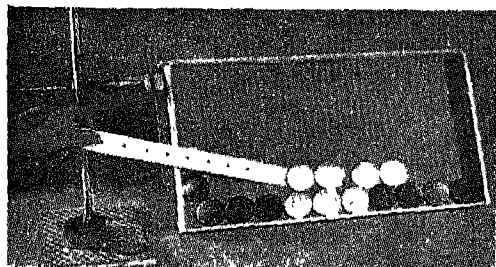
buting the learning materials was mainly to create an interest amongst the pupils for the course and to get their reactions to the presentation and language aspects.



(i)



(ii)



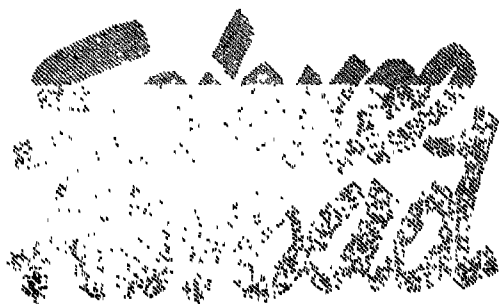
(iii)

Figure 2. (i), (ii), & (iii) Simple mechanical model to explain the elastic and plastic deformations of a substance on the basis of the particle model. Two rows of 'particles' are arranged in the tray. The upper row is disturbed by force which allows 'the particles' to regain their original shape when removed as in case of elastic deformation Fig 2(ii). A stronger force disturbs 'the particles' to change their neighbours from the lower row as in case of plastic deformation Fig 2 (iii).

Item of equipment available in the middle school and common materials easily available in the market were used to organise the demonstration experiments and pupil activities in the class. Analysis of the learning materials and the evaluation-record of the pupils, understandings about the concepts presented in the form of demonstration and developed through teacher pupil discussion, and of the pupil activities have enabled the authors to draw the following broad conclusions and make general observations:

1. The background knowledge mentioned above was sufficient to enable the average pupils to take interest in the study of the elements of the structure of substances. The average pupils were able to participate in the discussions that followed the demonstrations. However, it was observed that discussions, at times, had to be initiated with the help of bright pupils. The planned discussions yielded logical conclusions drawn by pupils with teacher's guidance.
2. Some modifications need be made in the course of general-science for the lower primary classes to strengthen the related topics.
3. Pupils showed a good deal of interest in the pupil activities and were able to co-relate the activities with the concepts of the topics covered in the class. The pupil experiments could be easily organised by grouping pupils in batches of two each.
4. Pupils' concepts about 'temperature' and 'pressure', 'plasticity of solids', and 'mobility of fluids' etc. formed during the experiment were found to be scientifically sound.
5. Study of these topics helped the pupils to show better response in the course of Biology and Chemistry.

6. Need was felt for taking help of film strips on titles like *molecular structure of substances* for providing some additional ideas to the pupils. Suitable films/filmstrips on titles related to molecular structure of substances need be produced for this stage.
7. Some of the pupils showed interest in further study of the '*molecular structure of substances*' and their properties. Suitable *Supplementary Readers* for the age group 11 to 13 years need be prepared for this purpose.



Nitrogen Fixation

JOHN POSTGATE,
Professor of Microbiology,
University of Sussex

Nitrogen fixation a strangely archaic name for one of the growing points of science. A process on the borderlines of biology and chemistry which has been known for well over a century but which has only begun to be understood in biochemical detail during the past ten years.

TO "fix" nitrogen is to convert nitrogen gas (N_2) into a combined form, solid, liquid or gaseous. Though the phrase can apply to chemical methods of making nitrogenous compounds from atmospheric N_2 , it usually implies a process whereby microbes in soil, sometimes in association with plants, convert N_2 from the Earth's atmosphere into a form which plants can use for growth. Such biological nitrogen fixation is an important part of the nitrogen cycle, familiar to every school child who has "done" Biology. This cycle, illustrated in Figure 1, is a formalization of the way in which the element nitrogen (N) undergoes cyclical chemical transformations brought about by living things. Plants build nitrates (NO_3^- -ions)

from soil into protein; animals eat plants and make different proteins mankind eats

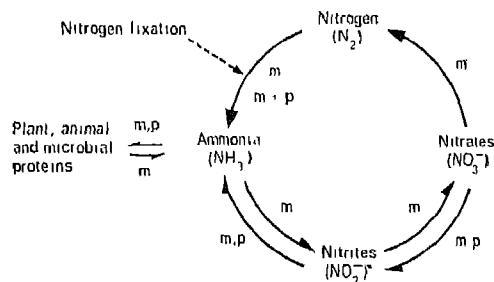
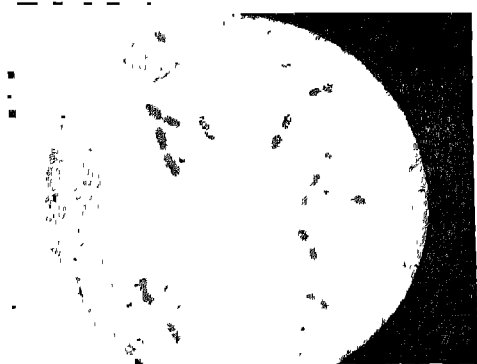


Figure 1 The diagram illustrates the major transformations undergone by the element nitrogen (N) through biological action. m indicates a change brought about by microbes, p changes brought about by plants, m+p indicates a symbiotic combination of both

both, but death and excretory processes ultimately pass the nitrogen over to microbes. Some of these release it as ammonia (NH_3), others as N_2 gas. Though plants can assimilate ammonia, they prefer nitrates and soil bacteria exist which oxidize NH_3 to nitrates by way of nitrites (NO_2^- -ions); some non-biological loss of nitrogen to the atmosphere occurs when nitrates and ammonia react in soil to form N_2 and water. The processes described so far lead to a net loss of N to the atmosphere and, if they were all that took place, all the biological N on this planet would by now be in the air as N_2 (and you and I gentle reader, would not be here). The agents responsible for reversing this loss are the nitrogen-fixing microbes, a heterogeneous group of bacteria and primitive algae which have little in common except the ability to bring N_2 back into chemical combination—to "fix" it.

The table illustrates the classes of nitrogen-fixing microbes. First come the free-living organisms found in soils; among these *Azotobacter* and its relatives, the blue-green algae and a very few species of *Mycobacterium* are the only representatives of aerobic

(air-breathing) microbes. The rest are either obligate anaerobes (microbes which grow and fix N_2 only where oxygen is absent) or facultative anaerobes (which can grow with or without oxygen but which fix N_2 when only oxygen is absent). Secondly come the symbiotic microbes, those which live in association with a plant. A relatively casual association with a plant. A relatively casual association of a N_2 -fixing blue-green algae with a fungus occurs in the lichens, enabling them to grow in such inhospitable environments as the roofs of houses. In the leaf nodule systems, certain species of *Klebsiella* a bacterium, grow in nodules on the leaves of tropical plants such as *Psychotria* and fix nitrogen there; how much this helps the plant



Azotobacter chroococcum, a free-living, nitrogen-fixing, soil bacterium. Phase contrast, X753

is not yet clear. The symbiosis in leguminous plants (such as lupins, clover, beans) is obligatory: legume roots become infected with bacteria called *Rhizobium*, which collect in nodules on the roots. Here H_2 is fixed; despite many efforts, no-one has succeeded in causing *Rhizobium* to fix N_2 outside the plant (nor the plant to fix without *Rhizobium*). The non-leguminous associations are even more obligatory: so far no one has clearly identified the organisms responsible

for N_2 fixation by the alder tree, bog myrtle and upwards of 120 other species of non-leguminous plants. But there is no doubt that microbes are involved and that nodules must be formed for N_2 to be fixed.

Biological nitrogen fixation is still the rate-determining step in food production in most parts of the planet. Except in highly industrialized countries, where artificial nitrogenous fertilizers are widely used, the rate at which symbiotic plants and free-living microbes return N to the soil determines the soil's productivity. On a global scale, something like 109 tons of N_2 are fixed annually by microbes. Mankind's factory-made fertilizers trap a little N_2 and so do chemical fixation processes (lightning generates oxides of nitrogen, so does the internal combustion engine, and rain washes these into the soil as nitrates); but taken together they account only for 1 or 2 per cent of the total N_2 fixed.

Nitrogen fixation is clearly of enormous economic importance, but its scientific interest extends beyond that. In the laboratory, N_2 is very unreactive. It takes harsh reagents such as red hot magnesium or an electric discharge to "break into" the N_2 molecule. How then, do these microbes, at soil temperatures and acidities, always in water, sometimes in the presence of air, cause N_2 to react chemically? We still do not know, but we are learning and, in the process, a new technique of enzymology has developed and a whole new class of transition metal complexes* has been discovered.

In 1960 a group of workers from the Central Research Laboratories of Dupont de Nemours (USA) obtained the first enzyme preparation able to fix N_2 in the test tube. It was an extract of the anaerobic bacterium *Clostridium pasteurianum* which, when pro-

* Elements such as iron, cobalt and nickel

vided with sodium pyruvate, converted N_2 to NH_3 . The extracts were inactivated by the oxygen of air and, to study them, techniques for concentrating, purifying and generally handling enzymes in the absence of air had to be developed. Some four years later, workers at the Charles Kettering laboratories, Yellow Springs, Ohio, obtained oxygen-tolerant preparations from the aerobic bacteria *Azotobacter* and today active extracts have been obtained from most of the microbes listed in Table I. An interesting and unexpected point is that the oxygen-tolerant preparations from *Azotobacter* consisted of tiny sub-cellular particles and these, when broken up in their turn, yielded water-soluble preparations quite as oxygen-sensitive as the *Clostridium* extracts. It seems that the enzyme is normally intolerant of oxygen, but that air-breathing microbes have developed a way of protecting it from oxygen by "wrapping it up" as a particle. The N_2 fixing enzyme, called "nitrogenase", has been concentrated and largely purified from four or five microbes and always consists of two proteins. One is large (molecular weight about 180,000) and contains the metals molybdenum (Mo) and iron (Fe,) the other is smaller (m w about 40,000) and consists of iron and nothing else. The second is the one which is easily damaged by oxygen; the first is generally tougher. Proteins from different microbes will cross react to some degree. For example, the Mo-Fe protein of *Klebsiella* will fix N_2 if mixed with the Fe protein of *Azotobacter*. But the two proteins of nitrogenase, whether from the same or different microbes, always require a supply of ATP to work. ATP is biochemists, shorthand for adenosine triphosphate, the biological "quantum" of energy; enzyme preparations consume as much as 15 molecules of ATP to reduce one N_2 molecule to two NH_3 molecules. This is an awful waste of

energy by biological standards (and seems thermodynamically unnecessary anyway) and when we understand why it happens we shall know a lot more about N_2 fixation than we do now.

A very important property of nitrogenase preparations is their ability to reduce things other than N_2 . N_2 has the triply-bonded structure shown in Figure 2, several other small molecules with triple bonds are listed there and all are reduced (given some ATP) by nitrogenase except for carbon monoxide, which inhibits the enzyme most effectively. While reducing them, nitrogenase evolves hydrogen (H_2) from water, which means that, during the reaction, a reducing agent is being formed powerful enough to donate electrons to the H^+ -ion. H_2 evolution is not prevented by carbon monoxide, which suggests that nitrogenase has at least two active centres, one where triply-bonded compounds stick and which can be blocked by carbon monoxide and another where a powerful reductant is formed which is immune to carbon monoxide. Other explanations are, of course, possible, but this seems the simplest at present.

The reduction of acetylene, discovered simultaneously by workers in Wisconsin, USA and Perth, Australia, is of great practical value in research because its product, ethylene, can be detected in minute amounts by gas chromatography. Acetylene reduction has suddenly provided workers in this field with a powerful tool for detecting nitrogenase and some unexpected results are emerging. Microbes earlier believed to fix N_2 , including yeasts and other fungi as well as bacterial of the genera *Pseudomonas* and *Azotomonas*, have proved not to be fixers at all—they are just scavengers of traces of fixed nitrogen in air or laboratory reagents. On the positive side extracts of legume nodules have been prepared which reduce

acetylene and which fix 15 N₂ (the heavy isotope of N₂) by workers in Australia and in Oregon, USA, and the nitrogenase from such systems has been shown to have two components like those from the free-living bacteria. Nitrogen fixation by the blue-green which have a special problem because they evolve oxygen during photosynthesis, has been shown to take place in special cells, large highly reducing, apparently empty bodies called heterocysts. The bacterium *Klebsiell* has been shown to be much more important as a fixer than was once thought, it is abundant in the rhizosphere around plant roots and may well use plant exudates for N₂ fixation and so help plant growth. Australian workers have found *Klebsiella* actually possessing nitrogenase (by the acetylene test) in the intestines of man and guinea pigs. British workers have detected acetylene-reducing bacteria (and hence presumptive N fixers) in the rumen of sheep and I have shown the reaction in pure cultures of certain rumen bacteria. A sort of symbiosis between microbes and animals, comparable to that known for decades in plants, is now a serious possibility.

Acetylene reduction has proved a powerful experimental tool, but on theoretical grounds some of the other reductions in Figure 2 are more interesting. Cyanide reduction discovered by the Dupont group, and particularly the reduction of methyl isocyanide discovered in my laboratory, give

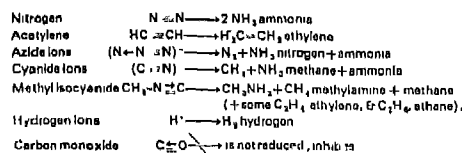
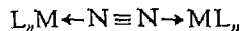


Fig. 2 Nitrogenase reduces many small molecules containing triple bonds. A notable exception is CO, which inhibits all the reactions involving triple bonds (presumably by blocking part of the enzyme) but not the reduction of H⁺ ions

rather peculiar products. Nitrogenase reduces methyl isocyanide (CH₃NC) to methane (CH₄) plus small amounts of C₂ products. Ordinary chemical reduction of methyl isocyanide would yield dimethylamine (CH₃NH, CH₃) and this is the interesting point if an isocyanide is first tied down in a metal complex, as in the platinum derivative Pt Cl₂ (C₆H₅NC)₂ (which is made from phenyl isocyanide) and then reduced, one gets the "biological" products: CH₄ and some C₂ gases. This sort of work suggests strongly that the metals in the protein components of nitrogenase are actually part of the active site on the molecule of enzyme. But how could transition metals react with N₂? A partial answer to this question has appeared over the last two or three years from an entirely different area of science: the study of inorganic metal complexes.

In 1966 the first transition metal complex was made, actually by accident which contains N bound to the metal. It was the ruthenium ion in Figure 3, called "Allen's compound" after its discoverer, Dr A.D. Allen of Toronto University. Shortly afterwards comparable complexes of osmium and iridium (both heavy metals like platinum) were discovered, but all were formed indirectly (from hydrazine or azide complexes). The first to be made directly, from N₂ gas was discovered in Japan and is the complex cobalt hydride in Figure 3. In all of these complexes the N₂ molecule retains its triple bond, one could write the general formula for them so: L_nM←N≡N—where M is a transition metal, L signifies ligands, which may or may not be the same, and n lies between 4 and 6. This year (1969) has been a positive deluge of such N₂ complexes and my chemical colleagues at Sussex University have contributed some of them. Binuclear complexes have also appeared of the form.



—in which the “M”s may not be the same. Figure 3 includes an example. Complexes of this kind may well be models for the way in which N is tied down by nitrogenase, but how is it reduced? It is a chastening thought that none of the 20 or so well-characterized metal N —complexes now known has been successfully reduced to give ammonia. Reducing agents either have no effect or they displace the N group as N gas.

Thus the chemical model, at present seems to break down at a crucial stage: we can show how nitrogenase could bind N but we cannot explain its reduction to ammonia. But in purely chemical terms the way ahead seems fairly clear: the $N \equiv N$ triple bond has a characteristic absorption of infra-red light at 2331 cm^{-1} . In new N_2 complexes this stretching “frequency”, as it is called, is altered. By making series of such complexes this stretching “frequency”, as it is called is altered. By making series of such complexes one can find examples with longer and longer stretching frequencies, down to about 1800 or 1700 cm^{-1} . In such complexes the $(-N \equiv N-)\leftarrow N \equiv N \rightarrow$ group is getting more like an azo-group $(=N=N-)$, with only a double bond between the N atoms. A typical azo-compound is azobenzene ($C_6H_5N=N-C_6H_5$) with a stretching frequency 1550 a^{-1} . Azo-compounds are easily reduced chemically.

So, in theory, we can now tell microbes how to fix N_2 . Tie it down as a complex of the form $L_nM \leftarrow N \equiv N$, with the enzyme protein supplying the “L”. Bring another metal in on the other side, carefully chosen so that the final complex is as little like $L_nM-N=N-ML_n$ and as much like $L_nM-N=N-ML_n$ as possible. Divert some electrons from the microbe’s normal electron trans-

port system into the complex so that the N atoms get negative charges, then let them pick up H^+ ions from water and the system is over the hump: $\leftarrow N \equiv N \rightarrow$, having become $-N=N-$, goes to $-NH-NH-$, then to $-NH_2\ H_2N-$, then $\leftarrow NH_3\ H_3N \rightarrow$. Release the ammonia as free HN_3 and round we go again.

Too easy? Quite so. But that is just one of several possible mechanisms one could suggest. Before we understand the

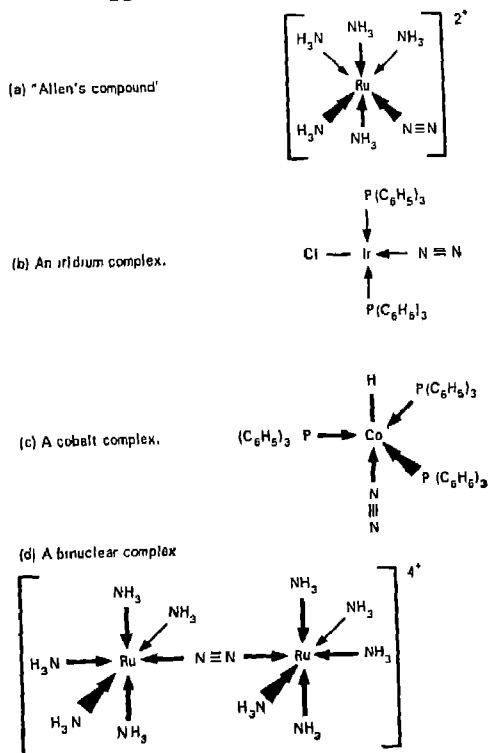


Fig. 3 Some N_2 complexes of transition metals. The stereochemical structures are conjectural, but probable, except for the cobalt complex, where it has been confirmed by X-ray analysis.

real one we have to answer many questions. Why is all that ATP used? Why are two proteins needed? How are water and oxygen, which would interfere drastically with the

early stages, kept out until needed?

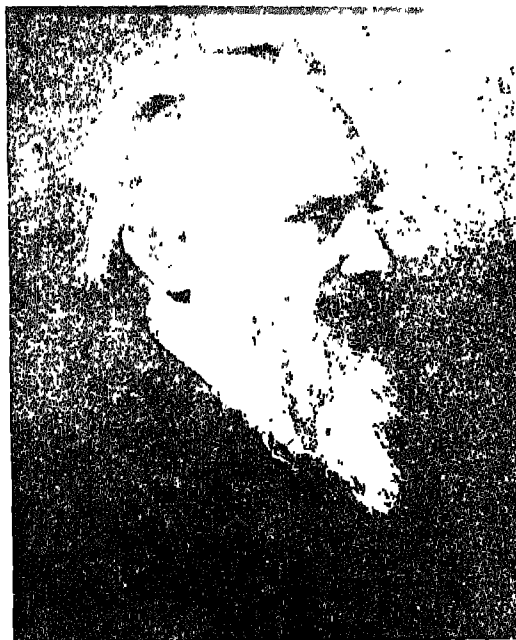
The important thing is that, today, we can put forward hypotheses of this kind which have some degree of plausibility, when even a couple of years ago we could not. And meanwhile a new class of metallo-enzymes has been discovered, techniques of anaerobic enzymology have been developed and a whole new class of inorganic N complexes has turned up. A fruitful collaboration of chemists and biologists has revealed new aspects of inorganic chemistry and enzymology which will have—indeed, are already having—repercussions far beyond the original field of nitrogen fixation.

Computer Simulation and Biological System

B. J. HAMMOND

National Institute of Medical Research, U.K.

THE collaboration between the brother Professors James and William Thomson, (who became Lord Kelvin), led to the first instance of computer simulation in 1876. James provided the elementary computer parts in the form of mechanical integrators whilst Kelvin showed how they could be interconnected to mechanise the solution of differential equations. This particular interest arose from the use of such equations to describe various physical situations; those mentioned by Kelvin in a companion paper to the Royal Society included vibrations in



Lord Kelvin. from portrait in the National Portrait Gallery, London.

flexible solids, in water and in air, together with the conduction of heat along non-uniform bars. In modern terminology, the physical situation, whether concerned with water waves or thermal conduction, would be referred to as the "system", the differential equations describing the situations would be termed the "mathematical model" and the computer configuration for solving the equations would then be a "computer simulation" of that system.

Although the means of computer simulation have evolved enormously in the present century, the stimulus for it remains essentially unaltered because, despite the ingenious efforts of mathematicians, the vast majority of equations describing real situations have no known analytic solutions. Any alter-

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native means of solution is therefore welcomed by those concerned with the quantitative description of systems, if the alternative means constitute a practical method of solving practical equations.

The difference between the use of computers as simulators and as data processors has become confused as greater number of more refined machines are applied in an ever increasing range of disciplines, but discrimination between the two types of use is clear if the type of information input and output are contrasted in each case. Data processing is well named since the input information is data concerning items and such items may be as diverse as bank cheques, insurance statistics or milk yield records; the output information is a selected sorted or otherwise processed version of the input data. When the computer is used as a simulator, however, the information, given to the machine in mathematical form, is a set of statements about the inter-relationships between the elements of a system, the output of the computer is the solution of the equations which represents information about the performance of the system. Such performance is determined entirely by the input statements about the internal relationships of the systems.

Engineers have been among the first to make use of computer simulation methods and as a result we have become familiar with the idea. It is also increasingly used in engineering design and it is in this that the engineer and pure scientist find themselves facing a common problem. Each is concerned to find a system whose parts interact to give the performance needed. In one case the required performance is given in the project specification book and in the other it is to be found as experimental observations in the laboratory notebook.

It is only a question of time before the

life sciences become exact sciences in the sense that they are founded upon demonstrable quantitative laws. In biology, the fundamental life science, evolution in this direction is well established and has reached a stage where modern biological research typically makes use of quantitative instruments and techniques borrowed from or at least largely originating from, the physical sciences.

One of the techniques that is finding a place in biological research is computer simulation which irreverently considers all things as systems, whether the system elements are atoms, molecules, bacteria, mice or men. Computer simulation is concerned simply with whether sufficient quantitative information is available to construct a tentative mathematical model to explain a phenomenon and then, by solving the mathematical equations, to check whether the performance of the model is indeed in accord with the observations. Much of the initiative in applying computer simulation to biological systems is being taken by errant engineers and physicists attempting to apply their technique into broader fields. On the other hand, there is a move on the part of individual biologists and their professional organisations to devise schemes which embody the new attitudes arising from modern biology and these schemes commonly invoke the idea of an organisational hierarchy of biological systems. In this situation, where the sort of thing expressed in figure 1 gives common ground, the computer simulation of biological systems, is a continually expanding subject. The hierarchy of figure 1 is of course by no means new, for traditionally it has been invoked to separate rather than link biology and physics. Now perhaps its role is reversed, not only in linking scientific subjects but, possibly of more importance, in bringing a greater variety of scienti-

fic workers into personal contact.

Increasing co-operation is producing a corresponding increase in the number and diversity of biological simulation studies to be found in world literature. Some of these studies are concerned specifically with medical aspects of biological systems. Though this speciality is still in its infancy it already shows great promise. Not only is computer simulation augmenting medical research but it is assisting in the diagnosis and prognosis of disease and may even eventually provide a means of improving therapeutic and surgical procedures. While these applications are still largely speculative, progress is being made towards their fulfilment and examples of this work may be taken not only to illustrate medical application but also to show the more general simulation of biological systems. Those given here are drawn from work carried out at the National Institute for Medical Research (London) and are chosen for their simplicity, and hence clarity of illustration, rather than as examples of the complexity of biological systems.

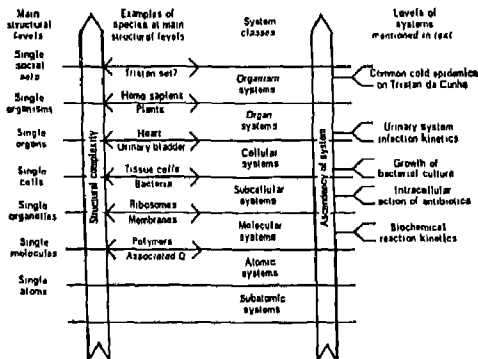


Figure 1. Hierarchy of natural systems; the ascendancy of a given biological system places it in one or other of the relevant system classes. The system must be composed of elements of lower ascendancy and these are frequently found to be either species of the main structural levels or their direct derivatives.

Figure 1 shows that those systems which

are commonly regarded as biological start at a level of ascendancy within the class of molecular systems, that is, within the province of biochemistry. At this overlap of physical and biological systems, biochemists (starting with Britton Chance in 1940) have pioneered in the application of computer simulation to biological systems. The formulation of mathematical models of biochemical systems invariably brings in the ever-expanding laws of biochemical kinetics. For example, first order kinetics have been applied to the system of Figure 2 to produce a computer simulation of the behaviour of the substance aminobutyric acid (GABA) which is found exclusively in brain tissue and is almost certainly one of a group of substances that effect the transfer of electrical pulses between individual neurones of the brain. Numerical adjustment of the simulation has allowed the solution of the solution model to fit closely with

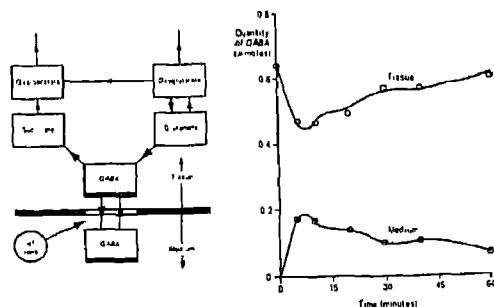


Fig. 2. Example of "molecular" system; the substance GABA is released by slices of brain tissue by addition of K^+ ions to the surrounding medium at time zero. Computer simulation of the system at left gives conjugate solutions shown by continuous line and are in good agreement with the circles representing experimental data.

experimental data coming from the work of Dr Robert Balazs of the Neuropsychiatric Research Unit, Surrey. Use of this and similar models has meant the evaluation of such crucial factors as the rate of GABA

formation under different biochemical conditions.

Work on the substance GABA has already led to consideration of its organisation as a system of higher ascendancy, that is, as a subcellular system. The reverse is true of another substance, dihydrostreptomycin or DHS, whose lethal effect on bacteria has long been recognised at the cellular level. Research is leading to resolution of DHS effects as a system of lower ascendancy and it is now generally accepted that at the subcellular level DHS irreversibly blocks the operation of the bacterial ribosomes which manufacture the cell's essential proteins. However, the work of Margot Kogut, now at King's College, University of London, has indicated that DHS is also bound, this time reversibly, to some other subcellular component. Mathematical models have been evolved using a computer to represent various systems that could be involved in the distribution of DHS between ribosomes and the unknown subcellular component X. Since the number of free ribosomes at any time determines, through protein manufacture, the growth rate of the bacterial population at any time, measured growth rate provides a means by which the computer simulation may be assessed. It appears that the component X intervenes between DHS and the ribosomes, rather than acting as an alternative destination for DHS and this in turn could imply that component X may be associated with the intracellular face of the bacterial membrane itself.

Just as computer simulations may represent the interactions of subcellular components, so simulations may be made representing the interactions of the organs that together constitute the higher organisms. An example of this is found in considering infections of the urinary system where the organs primarily concerned are the kidneys, leading

via their ureters into the bladder. As indicated in Figure 3, there may be residual infection sites in the upper system but even in their absence the bladder may become infected with a growing culture of bacteria. The figure also indicates the two basic means of treating this condition, namely, the maintenance of the patient on a high water intake and the administration of antibiotics.

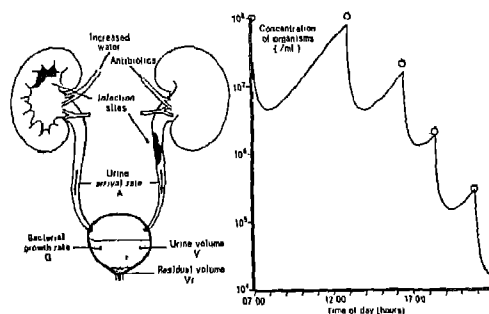


Fig 3. Example of "organ" system; the characteristic sigmoid growth curve of bacteria is modified in the human bladder both by the arrival of fresh urine from the kidneys and by the reduction of culture volume at times of urination. Computer simulations of the system provides a solution in good agreement with clinical data (open circles) obtained for a particular patient at times of urination.

building a mathematical model to relate the factors effecting the size of the bacterial population at any time, the basic concept is of a culture growing towards a known limiting concentration but opposed by continual dilution due to the addition of fresh culture medium passed from the kidneys. The system if further perturbed at times of urination when the volume of urine is reduced, at constant bacterial concentration, to a relatively small residual volume. In collaboration with Professor Francis I Grady of the University of London a computer simulation of such a system is being developed and its performance compared against clinical data giving the type of result shown in Figure 3.

The use of computer simulation has already led to fuller understanding of the infection kinetics observed in certain patients and could eventually lead to improved treatment of urinary bladder infections.

Even with a relatively simple organ system, such as this, the point is soon reached where no data is available against which to check the solutions of the mathematical model. With the quantification of biology the situation is slowly improving but the paucity of data is even more acute at the higher levels of organisation where biology merges with sociology. As at other system levels, it is still possible to compare the general performance features of mathematical model and real system but such procedures are notorious for their fallibility. However, recently a unique (at least in the author's experience) situation has arisen where a human system at the multi-organism level may be simulated and qualitatively compared with data on a realistic basis. Successive Medical Officers on the Island of Trisian da Cunha have collected, among other data, almost complete records of several common

cold epidemics occurring on the island. Taking into account the suspected source of infection, the communicability and other general features of the common cold, a model is being evolved in collaboration with Dr. D.A.J. Tyrrell of the Common Cold Research Unit which already shows the sort of agreement with field data. The rate and pattern with which infection spreads through the community is obviously dependent upon the social habits of the islanders and the studies so far show that, with the common cold, the community may be treated as a socially homogeneous group, that is, as a single social set in the sense of Figure 1.

Perhaps the present philosophy and the future promise of computer simulation may be discerned is the simple finding that the law which expresses the likelihood of molecule A approaching molecule B, and which is the basis of chemical kinetics, also seems to express satisfactorily the characteristic social intercourse of Taristan islanders and the form of their consequent common cold epidemics.



New X-Ray Assay for Mineral Processing

RECENT developments in instantaneous radioisotope X-ray assay techniques by the Australian Atomic Energy Commission are expected to have a considerable impact both in Australia and other countries. They are already in use in mineral processing plants at Broken Hill, New South Wales, and could lead to the introduction of automatic control based on on-stream analysis in many industrial processes.

In some industries automation is only possible if materials in the various process streams in the plant can be analysed continuously in sufficient time for automatic

feed-back to the master control. Traditional wet chemical methods of analysis are slow and the results are often not available until the day after sampling. Some years ago introduction of the X-ray spectograph reduced the delay to about 30 minutes but this is still too slow to allow corrective action to be taken in many mining and industrial processes

The radioisotope X-ray on-stream analysers installed at Broken Hill are the first in routine use in the world for the continuous analysis of slurries in mineral processing plants. The first equipment was installed on the floatation feedline at the North Broken Hill Ltd. lead-zinc plant in May 1968.

The Zinc Corporation has since installed a unit to determine the percentage of lead in slurry solids in a byline sample stream from their main floatation feed at its Broken Hill mill. The corporation hopes to extend radioisotope X-ray techniques to the continuous assay of lead and zinc in slurries of concentrates floatation feed and tailings. It will also test techniques of determination of lead content of partly crushed ore moving on a conveyor belt.

The Atomic Energy Commission reports that the radioisotope X-ray techniques also look promising for determining tin and copper in floatation feed and concentrates. The commission and the Australian Mineral Industries Research Association are jointly sponsoring research on the application of the method to the on-stream analysis of tin. Successful tests have been carried out at the Ardlethan Tin Plant in south-western New South Wales.

The first industrial use of the technique was at Port Kembla, New South Wales, where the Australian Iron and Steel Company is using it to measure the thickness of tin coating on steel. It is wasteful to apply more than the optimum coating in making tin-

late. The isotope method can detect changes as small as one tenth of a millionth of an inch in the thickness of the coating and so allow effective, economical quality control.

The principle of X-ray analysis is well understood. Atoms of each element present in a sample emit light of a characteristic wavelength when hit by X-rays. A measure of the quantity of each element present is obtained by measuring the intensities of the various wavelengths emerging from the sample.

Normal X-ray generators are expensive and bulky. The Australian Atomic Energy Commission's Isotope Division led by Dr. J.S. Watt, sought radioisotopes that produced X-rays of the type (wave length) suitable for such a method of analysis. Success was achieved by developing secondary X-ray sources activated by isotopes. The output of each secondary source is confined to a particular X-ray wavelength, and the source is chosen to suit the particular industrial application.

The compactness and cheapness of the X-ray generating units allows them to be placed at many sample points throughout a plant, thus eliminating the need for long sample pipelines. Information from these strategically located sensor heads can be transmitted electronically to a small computer in a control room and so provide a basis for automatic regulation of the whole process.

Potential benefits of the new X-ray techniques include savings of manpower, improved product quality, and economy in plant operation. The Australian Atomic Energy Commission has also made noteworthy progress in the application of isotope techniques to the measurement of gas flow rates and the tracing of movements of silt in harbours and rivers.

The Australian raven is now recognised as two species—*Corvus coronoides* (large

raven) and *C. mellori*). The difference was discovered when a pair of birds failed to react to a decoy call which had previously attracted apparently similar birds. Subsequent analysis of the territorial calls of these birds showed that the little raven utters twice as many 'caws' per unit of time as the large raven but lacks the prolonged ending of the latter's call. Recognition of the two species has led to much more detailed study and findings of consistent difference in plumage, beak—shape, dietary preferences and behaviour.

Another bird, the so-called frackled duck, has been reclassified. It is now known to be a primitive survivor of the ancestor to the entire anserine group (swans and geese). As such it is of particular taxonomic importance. Unfortunately, the species is becoming rather rare in Australia.

Physiological studies on the female red kangaroo (*Megaleia rufus*) have disclosed its ability to produce milk of two quite different compositions from two mammary glands at the same time. This happens when a new young is born while the mother is still nursing a large young that has left the pouch. The composition of the milk is constantly adjusted to suit the needs of the growing animal and each has its own test.

Yet another odd feature of kangaroos is that after fertilisation the embryo may stop developing after a few days and remain in a dormant condition for as long as five months in the case of the quokka (*Setonix brachyurus*) and up to 11 months in the tammar wallaby—truly an instance of suspended animation.

The tammar wallaby's performance exceeds the longest dormancy observed in any other mammal. This species is also phenomenal because it can drink sea water and maintain weight while eating dry food. The only other mammals capable of this are a

few species of very small rodents weighing only about one-hundredth of the weight of a tammar wallaby.

By Courtesy: Australian Information Service

Fuel-Cell Battery Support Life in Undersea House

A British-made fuel-cell battery has enabled divers to live for up to six days in an undersea house with no "umbilical cord" to the surface.

The House, rigid steel-frame structure covered by a flexible skin, has been submerged for several weeks off Malta while a team of scientists from two London colleges carried out experiments. The house was used by relays of divers.

The novelty of the structure lies in the fact that there are no air or power lines to the surface. Instead, there is a life-support module powered by a fuel cell battery designed and manufactured by Electric Power Storage Ltd., of Manchester. The cell powers the air-circulating motor, provides lighting and operates various instruments.

The battery manufacturers said yesterday that experienced divers could live in the house for six-day periods and carry out salvage work, exploration and scientific tests with a minimum of contact with supporting services on the surface.

By Courtesy: British Information Services

British Device to help in Study of Sun's Atmosphere

ULTRA-VIOLET (UV) radiation from the sun will be analysed by a British

device fitted in the orbital solar observatory which was launched at the week-end from Cape Kennedy, U.S.A.

The instrument should yield information of fundamental scientific interest and expand knowledge of the processes that take place in stars.

More knowledge could also help in possible future processes for producing—such as fusion—on earth.

The device is an ultra-violet spectrometer designed by Dr B E. Woodgate of London University's Mullard Space Science Laboratory

The ultra-violet light is broken up into a spectrum, and eight spectral lines spread across most of the UV range of wavelengths have been elected for study to provide information on the sun's atmosphere.

By Courtesy: British Information Services

Discovery of Sub-Atomic Particles

THE University of Sydney has announced the discovery of the existence of fractionally charged sub-atomic particles

The Head of the university's School of Physics, Professor Harry Messel, said further experimentation might relate the fractionally charged particles to what had been predicted to be the basic particle of all matter, the "quark".

The photographing of five sub-atomic tracks was announced at an international conference on cosmic rays in Budapest, Hungary, by the Head of the Falkner Nuclear Department of the School of Physics in the University of Sydney, Professor C.B.A. McCusker.

Simultaneously in Australia, Professor Messel issued a statement which said evidence

pointing to the existence of fractionally charged subatomic particles had been discovered.

The discovery could rank with the greatest scientific discoveries, Professor Messel said. Further experimentation would be carried out to substantiate the findings.

"The particles discovered by Professor McCusker and his team have a charge of two-thirds of that of an electron", Professor Messel said.

"No one has yet discovered the missing particle with the predicted charge of one-third.

"For us, conclusive progress for the existence of these particles would be to find a track for particles with a charge of one-third that of an electron.

"We are building new equipment that should enable us to discover the one-third particles if they exist."

By Courtesy: Australian Information Service

Giant Telescope for Southern Skies :

THE need of a large optical telescope to study the skies of the southern hemisphere are to provide "eyes" for the Parkes radio "dish" has been evident for many years. After protracted negotiations the Australian and British governments have agreed to build and operate jointly a 150-inch optical telescope at the National University's astronomical field station near Coonabarabran, New South Wales. It will rank second in size to the 200-inch Mount Palomar giant in California.

The project, which is estimated to cost over \$ 10,000,000 is scheduled for completion in 1973. The telescope will be of

conventional design and very similar to a unit now under construction at the Kitt Peak Observatory in Arizona, United States.

The existing 64-inch telescope at Mount Stromlo near Canberra does not fully meet the needs of Australian radio-astronomers, who have to call on the big optical telescopes in the U.S. to complement their observations. Compared to the northern hemisphere, the southern sky is relatively unexplored and world astronomers are eagerly awaiting information that can only be obtained from a telescope of the size now planned.

New Quasar Way Out

The most distant quasar yet discovered has been found by Australia's 210-foot radio telescope at Parkes, New South Wales, believed to be the brightest and most distant yet observed in the universe, quasar 0237223, as it is known is estimated to be 13,000 million light years away from the earth.

Astronomers are excited because spectrographic analysis has shown that the new project contains heavy metals such as chromium, nickel, cobalt, and iron which have not previously been identified in these mysterious bodies. Further studies may provide clues to the nature of quasars and throw important light on the origin of the universe.

The optical identification and analysis were done at the Palomar and Lick Observatories in California. A joint announcement of the discovery was made from the California Institute of Technology by Dr. J G. Bolton, Director of the Parkes Observatory, and cooperating American Scientists.

The Parkes radio-telescope found the first quasar. That was in 1962. Since then more than two hundred of these strange, far-distant objects have been found by radio-astronomers in Australia and elsewhere.

Dwarfism Corrected by Hormone

Five of eight Australian dwarfs have responded well to treatment with human growth hormone. The subjects chosen for treatment ranged in age from about 13½ to 24½ years. Two of the patients were female, but none of either sex had attained puberty. A fourteen year old girl who grew at a rate of a centimeter a month manifested the greatest response to the treatment. She, like most of her fellows, grew relatively rapidly at first but after a few months her growth slowed to a much lower rate. In some of the others it stopped altogether. However, when the dose of HGH was doubled to 5 milligrams three times a week growth resumed at a satisfactory rate in all but one of the dwarfs.

Only one of the eight completely failed to respond to the treatment. Two others added only 2.5 cm. to their height in a year as a result of the HGH. One of the remaining five has been on the course for three years and has maintained uniform growth rate of 4 to 5 cm per year throughout this period. Another two have been on HGH for two years. One of this pair has put almost 1½ cm to this height in his time and the other has added 8.5 cm.

So far no complications for the treatment have been observed. A question now concerning the physicians is when to withhold the HGH.

As long as the patients stay on it they will not begin to mature sexually. Attention has also had to be given to the psychological problems that have arisen as a result of the successful treatment. For example, the patients have had to be encouraged to start living more normal lives than they had been accustomed to lead.

Though HGH has been used before in a few recent instances with some success, the Melbourne trials are particularly impressive.

Not only were high growth rates attained but, more importantly, there was a high response rate to the treatment among the dwarfs chosen. HGH being a truly precious substance it still has to be isolated from human pituitary gland—should only be prescribed when it will most probably produce effective results. The Melbourne work has helped to clarify the criteria on which to select those pituitary dwarfs who will benefit from HGH. These include pre-pubescent, a growth rate of less than 5 cm per year, pituitary surgery before puberty, and when no other cause for dwarfism can be found.

By courtesy: Science News letter Australian High Commission, New Delhi

Natural Environment Research Council's First Report

THE earth, the seas, the atmosphere, inland waters and the living things in all of them—these make up the range of subjects covered in the first report of the Natural Environment Research Council (NERC), just published in London.

The Council was set up in 1965 to plan and carry out research in all the sciences that relate to man's natural surroundings.

The report briefly surveys the kind of areas in which it will organize work. For example, it says that the mineral resources of the sea and sea-bed are largely unknown and untapped. Yet it may be feasible to extract such elements as uranium, silver and gold from sea-water and dredge up solid lumps of manganese from the sea floor.

Urgent Problems

The countryside is vulnerable to pressures from agriculture, industry and cities. Yet

little understanding exists of how to use it, preserve it and enjoy it

Such problems must be tackled by scientists in many disciplines working together, says the report. And they are practical, urgent problems

Giving an example, the report says that during the 1920s parts of the North Atlantic Ocean rose in temperature. The result on Greenland cod was an increase of catch to around 400,000 tons a year. But there is now some evidence that the temperature is falling again. If this is true, says the report, it is important "to know as soon as possible the probable consequences, both in the sea and on the land".

In the 10 months since it began work—the period covered by the report—the NERC's main effort has gone into setting up committees to advise it. New committees established by it are concerned with geology and geophysics, oceanography and fisheries, hydrology and forestry and woodland research.

Central Task

The central task of the NERC and its committees has been to make the best use of resources and scientific manpower.

It has already bought a steam trawler and is fitting her out as a new oceanographical ship. It is re-equipping other vessels and laboratories in the same field and supporting with all means available to it the artificial rearing and cultivation of fish and shellfish.

Plans have been made for an increase of geological survey work, essential to help in the development of other countries, and for the improvement of techniques for probing the structure of the earth at greater depths

Hydrological work includes a study of the Indus basin and the building of cheap, automatic weather stations.

The Council is to set up a geochemical

centre in London which it claims will be the biggest in Europe.

The report says that the NERC will take over responsibility for the British Antarctic survey from April 1

ROY HERBERT

By Courtesy. British Information Services.

New Evidence for Extra-Terrestrial Life

SOME years ago two American scientists found what appeared to be fossil remains of life in meteorites. In their opinion these traces of life could not be due to contamination after the meteorites had arrived on Earth, because they were unlike any terrestrial life forms, although other experts did not accept this conclusion.

Now, two more scientists, this time in the United Kingdom, working in the chemistry department of Bradford University, have reported evidence of a different kind. They claim that their evidence being based on chemical analysis rather than visual observation of what look like fossils is perhaps more objective than the American work. Dr. Gordon Shaw and Mr. James Brooks have examined portions of two meteorites chemically and have found substantial traces of a complex chemical compound bedded deep within the meteorites. The compound—sporopollenin—is insoluble, so it is hard to see how it could have got in the meteorites especially in the quantities (up to 4 per cent) found by contamination.

Reaction to the findings has been cautious and some other chemists may dispute the provisional identification of the compound as sporopollenin. But while the scientists themselves emphasise that these are early

findings, they still regard them as powerful evidence for extra-terrestrial life.

One reason why it is surprising is that the most likely origin of these meteorites is the asteroid belt, a ring of irregular-shaped chunks of rock which orbit the Sun between Mars and Jupiter and which may represent a fragmented planet. These rocks could not be large enough to hold an atmosphere and are unlikely places for life to evolve, although it has been suggested that their interiors could be warmed up by radio-active elements. The findings add new interest to the search for traces of life on the Moon itself, because though unlikely theory is that the meteorites may have been thrown out from the Moon during some active phase. Another possibility is that the material from which the meteorites are made may have been thrown out from the Earth many millions of years

ago, in which case fossils on meteorites would not be extra-terrestrial.

Dr Shaw, however, has gone on in an article in *Nature*, to speculate on the possibility that the opposite may be true, and that life may not have evolved on Earth from inorganic compounds but may have been seeded here from the meteorites. In support of his speculation he points out that there is a surprising absence of the complex organic compounds which would have formed the first phase in the emergence of life in ancient rocks of the Earth corresponding to the time when life should have come into being. Altogether, although all these ideas are speculative, there is enough hard evidence here to re-awaken interest about life's origins on Earth.

JOHN NEWELL

From *Spectrum*, 67, 1969.

THE UNIVERSE

by

P.L. Bhatnagar

Foolscap quarto, pp vi+200, 1967

Rs. 6.50

A scholarly yet lucid account of the structure of the universe and its fascinating inhabitants—the galaxies, nebulae, stars and planets—with whom the author, Dr. Bhatnagar, is thoroughly at home. The book is profusely illustrated and carries with it six stellar charts.

Copies available from

Business Manager Publication Unit
National Council of Educational Research and Training
N.I.E. Campus, Sri Aurobindo Marg,
New Delhi 16

Secondary School Science Teaching Project

DR. M.F. KOLPAKOV, expert in Physics and Mr. G.A. Letourneau, Audio-Visual Expert joined in November, 1969. Work is progressing on the writing of text materials for class IX in physics, chemistry, biology and mathematics. Thirteen titles of textbooks for classes VI and VII have been revised for a reprint issue. Class VI textbook in physics has been completely revised and a new Teachers' Guide has been developed as a companion volume.

Meeting of the teachers of the experimental schools was held from October 14 to 27 and November 2nd to 3rd 1969. Each subject group met twice for the morning and

afternoon shift schools respectively and discussed the materials relevant to the subject that is being taught and also the future programmes

Unesco-Unicef Project

Under this project the dialogue between The Central Ministry Team and the State Departments of Education has continued. the following states were covered during this quarter

- | | |
|---------------------|------------------|
| 1. Punjab | 4. Rajasthan |
| 2. Haryana | 5. Bihar |
| 3. Himachal Pradesh | 6. Uttar Pradesh |

Mr. N.K. Sanyal and Mr. A.W. Torrie, Unesco/Unicef Consultant along with the representatives of the Ministry and Planning Commission held discussions with the respective Education Secretaries and Directors of Education. All these states have agreed to initiate this pilot project in 30 primary and 30-50 middle schools from the coming school year. The relevant instructional materials have been sent to the states and it has been decided that the NCERT is to supply equipment and kits for the experimental schools when the programme starts..

STUDY GROUPS

Mathematics Study Groups

The Mathematics Study Groups held an Editorial Board meeting at Jaipur in the 3rd and 4th week of October and another meeting of the Directors of Study Groups at Calcutta during the last week of December, 1969. During this period, the draft for Algebra Text for class VI was finalised and that for class VII was discussed chapter by chapter. Geometry Text for class V has been printed and those for classes VI and VII are under print. The Teachers' Guide for Geometry for class V has also been

printed and those for classes VI and VII are under print

Physics Study Groups

A meeting of the Directors of Physics Study Groups was held on 26th December, 1969. Physics Text for class VI has been finalised during this period. Demonstration and Experiments Kit for class V was also completed and is ready for being duplicated.

Chemistry Study Groups

A meeting of the Directors of Chemistry Study Groups was held from 23rd October to 31st November, 1969, at Hyderabad. During the period under review, Laboratory Manual and the students Text for class IX was discussed and the revised drafts were prepared in the light of discussions at the Directors' meeting.

Biology Study Groups

A meeting of the Directors of Biology Study Groups was held from 17th to 23rd November, 1969. The first draft for Book IV, V and VI (classes VIII, IX and X) was prepared during the period under review and discussed at the Directors' meeting. Suggestions were offered for revision and preparation of a final draft.

NATIONAL SCIENCE TALENTS SEARCH SCHEME

During this quarter the Science Aptitude Test and Essay for 1970 examination papers were got translated and printed into regional languages through the Associated Centres in different states. Arrangements were finalized for the examination which is to be held on January 4, 1970.

UNESCO FELLOWSHIP

Dr M.C. Pant, Head of the Department of Science Education proceeded to USSR on deputation for a period of two months under

a Unesco Fellowship on October 25, 1969. After spending two months in USSR he proceeded to U.K. under the British Council Programme for studying the curriculum project in England, Wales and Scotland. He returned to India on December 17.

Three other members of the Department have proceeded to USSR on a similar Fellowship for a period of six months. They are Dr. B.D. Atreya, Shri R.C. Sharma, and Shri S.P. Sharma. Shri Mohinder Singh, Fine Mechanic of the Central Science Workshop has also proceeded to USSR on deputation for specialised training under the Unesco Fellowship.

Russian Language Teaching

Arrangements were made for teaching Russian language through the courtesy of the Institute of Russian Studies. Miss Maria Cherevko continues to give Russian lessons twice a week from 9.00 to 10.00 A.M.

PARTICIPATION IN NATIONAL AND INTERNATIONAL CONFERENCES

1. International Union for Conservation of Nature and Natural Resources

Mr. S. Doraiswami, from the Department of Science Education and Professor S.A. Balezin and Dr. V.M. Galushin, Unesco Experts, attended the Working Meeting of the International Union for Conservation of Nature and Natural Resources held at Forest Research Institute, Dehra Dun on November 21 and 22nd, 1969. This was a meeting of the Education Commission of the IUCN. It discussed problems of Conservation of Nature in the school curricula in general and with regard to the environment. About ten foreign visitors also attended this meeting. Mr. S. Doraiswami read a paper on the "Problems of conservation of Nature in the curriculum of Indian Schools."

Professor S.A. Balezin read a paper on 'Chemistry and Conservation of Nature'. These two papers attracted lively discussions and the delegates were interested in the manner in which conservation of nature was taken care of in the teaching of sciences at the school level.

The 10th General Assembly Meeting of the International Union for Conservation of Nature and Natural Resources was held at Vigyan Bhawan, New Delhi from November 24 to December 1, 1969. The Conference was inaugurated by the Prime Minister Smt. Indira Gandhi. The Conference had discussions of its several sections on different days and the meeting of the Education Commission was fixed for November 28, 1969. At this meeting as well as in the meeting at Dehra Doon the books produced by the Department of Science Education on science subjects for middle schools and primary schools were displayed. The delegates showed a very keen interest in these books.

At a business meeting of the Education Committee Mr. S. Doraiswami was elected as a member for India on the Education Committee of the IUCN. Two other Indian scientists were also appointed on this Committee. Dr. V.M. Galushin was elected member to represent the UNESCO.

2. Annual Conference of the All India Science Teachers Association

The Department of Science Education was represented by Shri S. Doraiswami and Shri K.J. Khurana at the Annual Conference of the A.I.S.T.A. held at Bangalore from December 25 to 27. On the 26th afternoon Shri S. Doraiswami read a paper on the "Projects for Improvement of Science Education undertaken by the NCERT and the progress achieved so far in these projects". He explained the steps that are

being taken to project the materials to the States as a pilot programme at the first instance. So far over a dozen States have already decided to use the NCERT science materials at the primary and middle school stage on a trial basis. Shri K.J. Khurana gave an idea of the package programme of the NCERT curricular materials, an integral part of which was the science kit. He demonstrated the utility and convenience of the Physics kit through which the entire physics programme of Class VI could be taught through experiment and demonstration. The kit and the textbook in primary science developed by the NCERT were also exhibited. The exhibits attracted the attention of both delegates and visitors and also the students of the locality.

CENTRAL SCIENCE WORKSHOP

Design of the proto-types of class VIII Secondary Science Teaching Project remained



Shri V.V. Giri, President of India, awarding this certificate of Merit to NCERT Staff in the Children's International Fair. Shri D.R. Dua is receiving the same on behalf of the Central Science Workshop.

in progress. A ray box has been designed which will enable all the experiments on optics to be performed.

Production of 300 Physics kits for class VII was completed according to the schedule.

Production 750 Biology kits and 250 Mathematics kits for class VI was taken on hand and has progressed satisfactorily

Production of 500 Physics kits for class VI has been undertaken.

A kit guide for Physics kit for class VI has been finalised. It contains the names of the various parts, list of experiments and a pictorial view of the parts along with the part number.

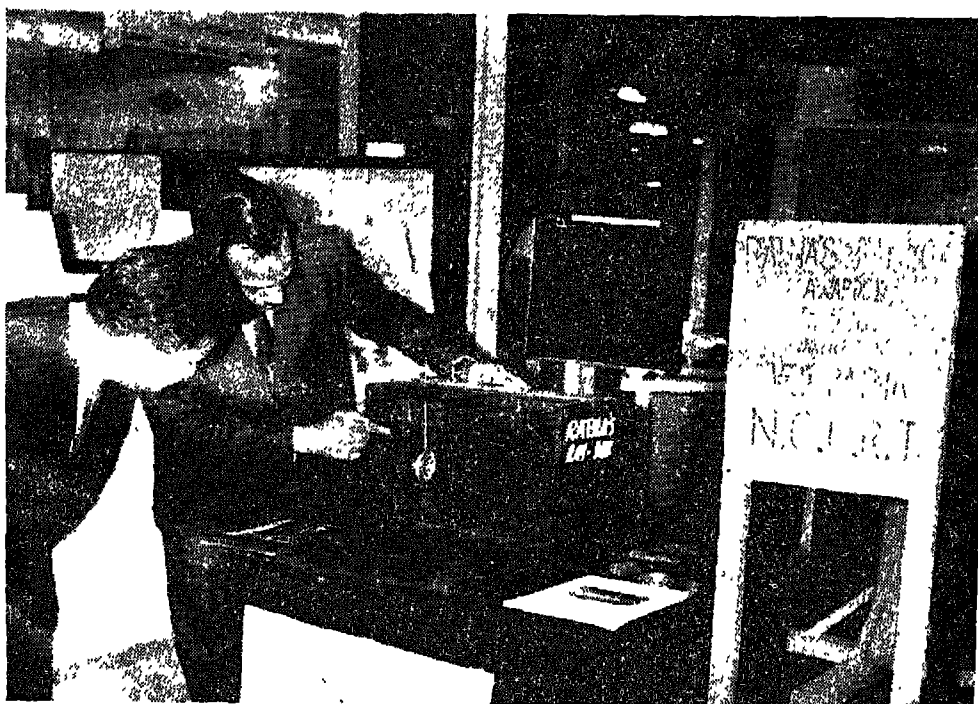
Under the charge of CSW, NCERT

participated in the Children's International Fair held on October/November, 1969. The stall was awarded a merit certificate.

Collaboration with other Departments of the N.I.E.

Members of the Department participated in the workshops on textbook production organized by the Department of Textbooks in the month of November. Shri S. Doraiswami attended the Biology Workshop, Shri K.J. Khurana, Physics Workshop, and Shri R.C. Saxena the Mathematics Textbook Workshop.

Shri R.C. Saxena also took part in the workshop organized on "Population Educa-



Shri Ved Ratna of the Department of Science education, NCERT, explaining the working of the "Ratna's Ray Box" devised by him at the 'Self Reliance' Pavilion of Gandhi Darshan

tion" organized by the Central Bureau of Health Education of the Ministry of Health, from December 1 to 6, 1969. He also visited Bombay to review the film on "Circles" produced by the Films Division of the Ministry of Information and Broadcasting.

Gandhi Darshan

Shri Ved Ratna of this Department put on display his invention "Ratna's Ray Box" at the 'Self Reliance', Pavilion of Gandhi Darshan. With the help of this equipment any experiment in Optics can be demonstrated to a class in a three dimensional way during day time without darkening the classroom. The paths of the beams of light in the experiment are made visible with the help of smoke.

Important Visitors to the Department

During the last three months the following distinguished educationists from foreign countries as well as from different states of India visited the Department of Science Education to study the science curriculum programmes, the equipment and kits developed and the Central Science Workshop.

1. Dr. Philip Lange, T C C U, Columbia.
2. Mr. Desmond P. Wedberg, University of Maryland.

3. Dr. J. Damien Teston, Marbel College, Philippines.
4. Professor Humiki of the National Science Foundation.
5. Miss Pasricha, Deputy Director, Public Instruction Himachal Pradesh.
6. Prof. J. A. Campbell, Unesco Regional Expert for Science Teaching.
7. Mr. Richard Greenough, Press Division, Bangkok, Unesco.
8. Madam Dominique Roger, Information Directorate, Unesco.
9. Mrs. Muller, Social Science Group Coordinator, U.S.A.
10. Dr. Isabel W. Diddle, Los Angeles.
11. Dr. Virginia Lewis, N. Carolina.
12. Dr. Schlesnick with Miss Hanna, U.S. Aid, New Delhi.
13. Prof. Moeller, East Germany.
14. Japanese Youth Goodwill visit—leader Mr. Katsunoburo Konishi.
15. Dr. D. K. Mathur, Director, State Institute of Education, Rajasthan.
16. Professors Karim & Azim of Afghanistan.
17. Mr. Gajwani, D.P.I., Sikkim.
18. Mr. P. S. Kohli, D.P.I., Bihar.
19. Field Officers of the Directorate of Education, Delhi.
20. Participants of Programmed Learning Workshop.

